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MICHIGAN STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

THE QUARTERLY BULLETIN

The Quarterly Bulletin of the Michigan Agricultural Experiment Station is issued in February, May, August and November. It presents progress reports on long-term major research projects and final reports on short-term projects.

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THE QUARTERLY BULLETIN

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MICHIGAN STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

C. M. HARDIN, DIRECTOR
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HALF-AND-HALF HOMOGENIZED MILK

By G. M. TROUT and BERNARD WEINSTEIN
DEPARTMENT OF DAIRY

CONSIDERABLE interest has been shown by several Michigan market milk distributors in a relatively new homogenized milk product commonly known as "Half-and-Half". Other names associated with this product throughout the country are, "Breakfast 'cream'", "Cereal 'cream'", "Cereal treat", or "Cereal milk". The trade names "Mel-O-Rich" and "Tasty-Rich" generally refer to this product as well. The trade mark and name "Half 'N' Half" were registered with the Michigan Department of State by the Pure Seal Dairy, Flint, Michigan, in 1944 (Bobier, 1948). Half-and-half homogenized milk is in reality a very rich standardized milk testing from 9 to 12 percent fat, approximately half way between coffee or table cream and milk in richness, hence its name.

Half-and-half homogenized milk has been well received by the consumer since it may be used with utmost satisfaction both in coffee and on cooked and prepared breakfast cereals. Bobier (1948) stated that the sale of butterfat has been materially increased by the sale of cereal milk. In this market the prevailing cereal milk tested 9 percent fat. Colebank (1949), reviewing the cream sales in packaged form for January in the metropolitan Chicago area, showed that the product "commonly known as 'half-and-half', '12% milk' or '12½% milk' accounted for the use of approximately as much butterfat as is used for regular and heavy cream." He stated, "Six years ago the amount of fat used in this product was negligible. The amount of butterfat now used in the form of so-called heavy cream and regular cream is roughly one-half of the amount used in 1940-1941." He presented sales data for the month of January over a ten-year period in the metropolitan Chicago area. These are given in Table 1.

ARTICLE 33-10

TABLE 1—*Butterfat pounds used in products commonly known as "Heavy Cream," "Regular Cream," and "Half and Half" in January of each year, 1940-49, inclusive, under Federal Milk Order No. 41* (Chicago area)*

(Thousands of pounds of butterfat)

	6—16%	16—30%	30% and over	Totals
January 1940	.....	1,161	210	1,371
January 1941	.....	1,236	296	1,532
January 1942	.....	1,160	216	1,376
January 1943	55	1,087	.....	1,142
January 1944	113	812	.....	925
January 1945	188	887	.....	1,075
January 1946	410	1,090	179	1,679
January 1947	520	810	132	1,462
January 1948	623	742	123	1,488
January 1949	695	590	118	1,403

*Data for 1940, '41, '42, and '49 are based on handler reports; data for 1943-1948 are based on audits.

As for processing half-and-half homogenized milk, Ruehe (1941) advised as follows:

> The usual way of preparing this product is to standardize milk or cream to 10 percent fat, add about 2 percent high quality skim milk powder; pasteurize at 150° F. for 30 minutes, cool to 115 to 125° F. and homogenize under 2500 pounds pressure. Then cool and bottle. The finished product will contain 10 percent of fat and about 10 to 11 percent of serum solids. It is necessary to homogenize at a low temperature in order to produce sufficient viscosity and body. The homogenizing temperature can be raised somewhat if less viscosity is wanted. According to the dairy standards of most communities this is a substandard product and therefore must be so labeled and the fat content declared on the bottle cap. If serum or milk solids are added, this also must be stated.

He (1948) stated that in Illinois the product must contain 10½ percent fat if it is to be sold as "half-and-half". Since this is a homogenized product churning is difficult. Thus, returns must be used other than as churning cream. Ruehe (1948) recommended that returns of half-and-half can be used for creaming cottage cheese and also as a source of fat for buttermilk.

The laws of the Michigan Department of Agriculture (Milk Requirements Act No. 169, Public Acts of 1929) relating to milk do not define half-and-half or specify standards for it. Apparently, therefore, regulations pertaining to the sale of milk in the state of Michigan apply to this product as well. Thus, the fat, milk solids-not-fat and specific gravity must be at least 3.0 percent, 8.5 percent and between 1.029 and 1.033 specific gravity, respectively.

A milk product standardized to 10-percent fat without standardizing the solids-not-fat accordingly, will be under the legal milk requirements for milk solids-not-fat and for specific gravity. Consequently, milk solids-not-fat must be added to bring the milk-solids-not-fat and the specific gravity up to the standards for milk. Calculations have been made for those desiring to market a 10-percent half-and-half cereal milk which reveal the various combinations of milk, cream, condensed skimmilk and/or non-fat dry milk solids that must be compounded to meet the specific gravity requirement, which seems to be the limiting factor. The values are presented in Tables 2 to 5 inclusive. All solids-not-fat calculations are based on 9-percent serum solids of the milk, 9 percent of the serum of the cream, the specific solids-not-fat percentage for condensed skimmilk, and 100-percent non-fat dry milk solids. Data in Tables 2 and 4 show combinations yielding the minimum specific gravity requirements, whereas data in Tables 3 and 5 show combinations yielding the average specific gravity of milk. From these calculations it appears that the addition of approximately 10-percent condensed skimmilk or 2-percent non-fat dry milk solids is necessary to bring the specific gravity of a 10-percent fat mixture to that of average milk, 1.032. Because additional tables would be too voluminous to include herein, similar data are not presented for 9-, 11-, or 12-percent cereal milk.

Since this product is homogenized, attention should be called a) to the possibility of the occurrence of the "sunshine" or activated flavor if the product is unduly exposed to light, and b) to the "feathering" of half-and-half homogenized milk in coffee if excessive homogenizing pressures are used. Homogenized milk is more susceptible to light than is nonhomogenized milk. Also, homogenized cream is more likely to curdle in coffee than is nonhomogenized cream.

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TABLE 2—*The combinations of milk, cream, and condensed skimmilk which will yield 100 pounds of a final mixture testing 10 percent fat and 9.4 percent solids-not-fat. (The specific gravity of such combinations will be approximately 1.029.)*

Milk products used to make 100 pounds					
Milk		Cream		Condensed skimmilk	
Percent fat	Pounds	Percent fat	Pounds	Percent SNF*	Pounds
3.5	46.5	18	46.3	27	7.2
	46.7	18	46.5	28	6.8
	52.2	20	40.6	27	7.2
	52.4	20	40.8	28	6.8
	74.5	40	18.3	27	7.2
	74.7	40	18.5	28	6.8
4.0	48.2	18	44.6	27	7.2
	48.4	18	44.8	28	6.8
	53.8	20	39.0	27	7.2
	54.0	20	39.2	28	6.8
	75.6	40	17.2	27	7.2
	75.8	40	17.4	28	6.8
4.5	50.0	18	42.8	27	7.2
	50.2	18	43.0	28	6.8
	55.2	20	37.6	27	7.2
	55.4	20	37.8	28	6.8
	76.7	40	16.1	27	7.2
	76.9	40	16.3	28	6.8
5.0	51.9	18	40.9	27	7.2
	52.1	18	41.1	28	6.8
	57.4	20	35.4	27	7.2
	57.6	20	35.6	28	6.8
	77.7	40	15.1	27	7.2
	77.9	40	15.3	28	6.8

*SNF = solids-not-fat.

TABLE 3—*The combinations of milk, cream, and condensed skimmilk which will yield 100 pounds of a final mixture testing 10 percent fat and 10 percent solids-not-fat. (The specific gravity of such combinations will be approximately 1.032.)*

Milk products used to make 100 pounds					
Milk		Cream		Condensed skimmilk	
Percent fat	Pounds	Percent fat	Pounds	Percent SNF*	Pounds
3.5	42.4	18	47.1	27	10.5
	42.7	18	47.3	28	10.0
	48.2	20	41.3	27	10.5
	48.5	20	41.5	28	10.0
	70.9	40	18.6	27	10.5
	71.2	40	18.8	28	10.0
4.0	44.0	18	45.5	27	10.5
	44.3	18	45.7	28	10.0
	49.7	20	39.8	27	10.5
	50.0	20	40.0	28	10.0
	71.9	40	17.6	27	10.5
	72.2	40	17.8	28	10.0
4.5	45.6	18	43.9	27	10.5
	45.9	18	44.1	28	10.0
	51.3	20	38.2	27	10.5
	51.6	20	38.4	28	10.0
	73.0	40	16.5	27	10.5
	73.3	40	16.7	28	10.0
5.0	47.4	18	42.1	27	10.5
	47.7	18	42.3	28	10.0
	53.0	20	36.5	27	10.5
	53.3	20	36.7	28	10.0
	74.0	40	15.5	27	10.5
	74.3	40	15.7	28	10.0

TABLE 4—*The combinations of milk, cream, and non-fat dry milk solids which will yield 100 pounds of a final mixture testing 10 percent fat and 9.4 percent milk solids-not-fat. (The specific gravity of such combinations will be approximately 1.029.)*

Milk products used to make 100 pounds					
Milk		Cream		Non-fat dry milk solids	
Percent fat	Pounds	Percent fat	Pounds	Percent SNF*	Pounds
3.5	53.4	18	45.2	100	1.4
	58.9	20	39.7	100	1.4
	80.7	40	17.9	100	1.4
4.0	55.3	18	43.3	100	1.4
	60.8	20	37.8	100	1.4
	81.8	40	16.8	100	1.4
4.5	57.4	18	41.2	100	1.4
	62.7	20	35.9	100	1.4
	82.9	40	15.7	100	1.4
5.0	59.6	18	39.0	100	1.4
	64.8	20	33.8	100	1.4
	84.1	40	14.5	100	1.4

TABLE 5—*The combinations of milk, cream, and non-fat dry milk solids which will yield 100 pounds of a final mixture testing 10 percent fat and 10 percent solids-not-fat. (The specific gravity of such combinations will be approximately 1.032.)*

Milk products used to make 100 pounds					
Milk		Cream		Non-fat dry milk solids	
Percent fat	Pounds	Percent fat	Pounds	Percent SNF*	Pounds
3.5	52.6	18	45.3	100	2.1
	58.1	20	39.8	100	2.1
	79.9	40	18.0	100	2.1
4.0	54.4	18	43.5	100	2.1
	59.8	20	38.1	100	2.1
	81.0	40	16.9	100	2.1
4.5	56.5	18	41.4	100	2.1
	61.8	20	36.1	100	2.1
	82.2	40	15.7	100	2.1
5.0	58.7	18	39.2	100	2.1
	63.9	20	34.0	100	2.1
	83.3	40	14.6	100	2.1

THE BUSINESS SIDE OF MICHIGAN FARMING, 1940-49[1]

By K. T. WRIGHT and J. C. DONETH
DEPARTMENT OF AGRICULTURAL ECONOMICS

THE BUSINESS side of farming has changed tremendously during the the past 10 years. Gross incomes trebled from 1940 to 1947, the peak year, and since then have declined about 10 percent (Fig. 1). Total expenses have continued to rise each year, and were 3¼ times greater by 1949 than in 1940. This figure excludes the farmer's own labor and interest on investment.

Labor incomes, or the net return for the farmer's labor and management, increased from $800 in 1940 to nearly $3,500 in 1947, the latter also being the peak year for net earnings, too. Lower gross incomes and rising expenses reduced the labor income figure to $1,800 by 1949 (Fig. 1). These financial results were obtained from farm records kept by farmers in cooperation with Michigan State College. The farms were larger and better managed than the average farm business. The exact figures for each year are shown in Table 1.

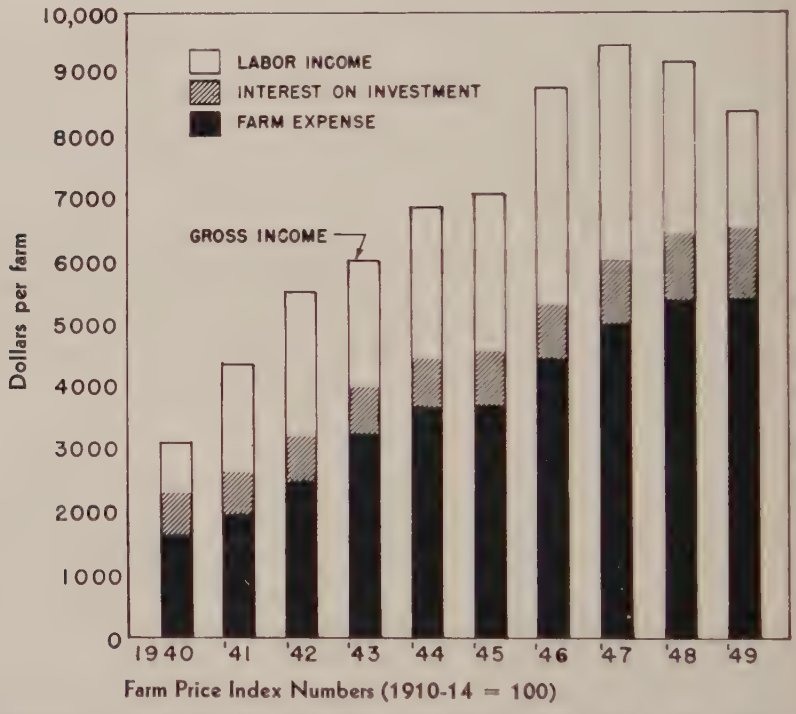
PRICES

The variation in prices received by farmers for their products was the major factor responsible for the change in gross farm income. In some year during the decade, the prices of some products were four times 1940 prices. In fact, the index of prices received by farmers in Michigan, which is an average of all products of any significance, was 306 for 1948, the peak year of the decade, compared with 106 for 1940 (1910-14=100). Prices paid by farmers for products and services they use also rose during this period, and in 1948, were slightly over twice those of 1940.

[1]Based upon the farm account records kept in the different type of farming areas of Michigan, in cooperation with the Extension Service.

EXPENSES

The expense of running farms, including cash operating costs, depreciation on buildings and personal property, as well as the value of operators' and family labor, increased from about $20 per tillable acre in 1940 to $50 in 1949. This does not include interest on the investment. The index of prices paid by farmers was about twice as high in 1948 and 1949 as in 1940. The expense items increasing the most during this period were labor, machinery, feed, and expenses on crops (Fig. 2). The increase in these expenses made up 90 percent of the total increase in expenses. While the expense of maintaining improvements was not large, new buildings or major repairs are now costly and add significantly to fixed overhead.



	1940	'41	'42	'43	'44	'45	'46	'47	'48	'49
Michigan Farm Prices	106	129	161	202	199	211	242	294	306	259
Prices Paid by Farmers*	124	132	152	170	182	189	207	240	259	250
Parity Ratio†	85	98	106	119	109	112	117	122	118	104

Fig. 1. Average gross farm income, labor income, interest on investment, and total farm expense on accounting farms in Michigan; and farm price index numbers, 1940-49.

*By farmers in U. S.
†Prices received by farmers in Michigan divided by prices paid by farmers in the United States. (The latter includes prices paid, interest, taxes, and wage rates.)

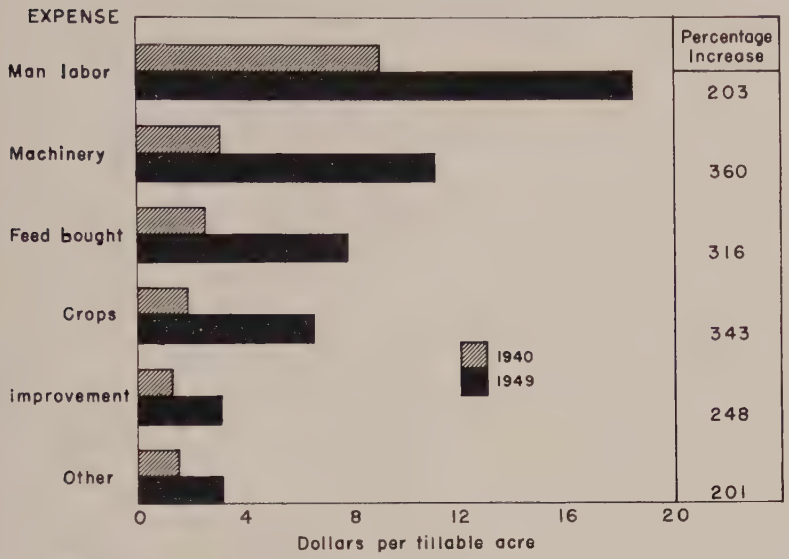


Fig. 2. Expenses per tillable acre on farms account farms in Michigan in 1940 and 1949, with the percentage increase.

OTHER CHANGES

Other changes in the farm business during this decade, as shown by the averages of the farms in this project, are shown in Table 1. Some of the more important were in the following: size of farm, intensity of operation, labor efficiency, investment, crops grown, and livestock returns.

The average size of the farm operated increased nearly 30 acres, or about 16 per cent. Total days of productive work per farm, another measure of size, increased only 5 percent, indicating less intensive operation. This reduced intensity is further indicated by the change in acres of tillable land per unit of productive livestock. This changed from 4.6 to 5.3 acres per unit of livestock, or a reduction in intensity of about 15 percent.

Labor efficiency increased to an average of 292 productive days work per man in 1949, or 21 percent over 1940. Gross income per man increased to three times that of 1940, due to higher prices for farm products and greater efficiency.

The investment in machinery per farm in 1949 was three times that of 1940, even though old machinery still on hand was not revalued because of increase in prices. Total farm investment was nearly double, according to the books, and that is a gross understate-

TABLE 1—*Averages of all accounting farms in Michigan, 1940-49*

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	1,263	1,041	1,160	1,097	1,031	939	838	830	846	912
SIZE OF BUSINESS										
Total acres per farm	170	175	176	185	193	195	195	193	196	198
Tillable acres per farm	112	117	117	122	129	131	133	134	136	136
Productive days work per farm[1]	452	467	464	480	506	490	498	473	466	477
Productive days work per man[2]	242	254	262	269	286	286	284	286	281	292
Gross income per man	$1,637	$2,300	$3,070	$3,343	$3,819	$4,150	$4,843	$5,548	$5,395	$4,939
Average number of men	1.9	1.9	1.8	1.8	1.8	1.7	1.8	1.7	1.7	1.6
Machinery investment per farm	$1,574	$1,788	$2,034	$2,256	$2,396	$2,590	$2,872	$3,315	$3,876	$4,758
Total farm investment	$13,638	$14,076	$14,846	$15,964	$16,900	$17,538	$18,628	$19,764	$21,568	$23,346
CROPS										
Percent of tillable acres in:										
Sod crops[3]	46	44	43	45	43	43	44	44	42	43
Corn	15	14	16	15	18	17	18	17	16	17
Wheat	7	7	6	6	8	9	8	12	13	12
Oats and barley	13	15	16	13	14	16	17	12	15	16
LIVESTOCK										
Productive animal units	24.0	26.1	25.6	27.6	27.9	26.5	27.8	27.1	23.9	25.6
Tillable acres per P.A.U.	4.6	4.4	4.5	4.3	4.5	4.9	4.8	5.0	5.7	5.3
Dairy product sales per cow	$102	$125	$146	$176	$209	$226	$267	$282	$297	$266
Hog income per litter[4]	83	155	214	171	240	213	288	393	327	227
Sheep income per ewe	11	14	17	13	13	15	23	20	21	21
Egg sales per hen	2.10	2.78	3.59	4.19	3.95	4.86	4.62	6.03	6.50	5.94
INCOME (per farm)										
Crops[5]	$891	$1,300	$1,737	$1,684	$2,215	$1,948	$2,641	$2,663	$2,223	$2,085
Livestock	2,051	2,868	3,597	4,123	4,448	4,893	5,856	6,418	6,531	5,897
Other	168	202	192	210	212	214	221	351	415	387
Gross income	$3,110	$4,370	$5,526	$6,017	$6,875	$7,055	$8,718	$9,432	$9,172	$8,369
Total expense	$1,641	$1,991	$2,481	$3,229	$3,624	$3,696	$4,413	$4,958	$5,358	$5,386
Net Farm Income[6]	1,469	2,379	3,045	2,788	3,251	3,359	4,305	4,474	3,814	2,983
Labor Income[7]	787	1,675	2,303	1,990	2,406	2,483	3,371	3,486	2,735	1,815
EXPENSES (per tll. acre)										
Man labor, all	$9.08	$9.21	$12.99	$15.84	$16.19	$15.33	$16.89	$18.70	$19.06	$18.51
Machinery[11]	3.06	3.66	4.23	4.98	5.55	6.08	6.92	8.66	10.03	11.02
Improvements[12]	1.25	1.30	1.43	1.75	1.89	1.91	2.38	2.60	2.74	3.10
Feed bought	2.47	3.66	5.03	7.47	6.74	6.80	6.91	9.17	8.75	7.81
Crops (fert., seed, etc.)	1.88	2.14	2.92	3.26	3.86	4.14	5.56	5.74	6.34	6.45
Taxes on property	.70	.70	.70	.71	.74	.78	.88	.96	1.01	1.08
Other items	.88	.93	.96	1.13	1.30	1.36	1.56	1.61	1.89	2.10
Total[13]	$19.32	$21.60	$28.26	$35.14	$36.27	$36.40	$41.10	$47.44	$49.83	$50.07
Gross income per tll. acre	27.65	37.45	47.07	49.43	53.29	54.37	65.39	70.30	67.44	61.59

EXPLANATION OF CERTAIN TERMS IN TABLES 1 AND 2

[1]Productive days work per farm is based upon the kinds and acres of crops, the kinds and numbers of livestock, and the work off the farm. Standard rates are used on all farms. Productive days work per man is the per farm figure divided by the average number of men working on the farm for the year. Productive days work has not been calculated for fruit farms. Thus, the three items with footnote 1 are not available for fruit farms.

[2]Machinery and total investment per farm are the "book values." They are less than current values, as machinery and buildings owned when the record was started have not been raised, and neither has the value of the real estate been changed.

[3]Sod crops include hay, tillable pasture, and grass seed.

[4]Hog income per litter is the net cash income, plus inventory change, divided by the number of litters. It includes any income from feeder pigs.

[5]Sheep income per ewe is the net cash income from lambs and wool, plus inventory change, divided by the number of ewes. Feeder lamb income is included.

[6]Crop income is total sales, plus inventory change.

[7]Livestock income is the net cash income, plus inventory change.

[8]Total expense per farm includes cash operating expenses, depreciation on buildings, machinery and any other items, as well as the family labor on farm work. Two items not included are the value of the farmer's own labor and interest on the farm investment.

[9]Net farm income is the difference between gross income and total farm expense. It is the return for the farmers' labor and management, and for interest on the farm investment.

[10]Labor income is the net farm income less interest on the farm investment, and is the return for the farmer's labor and management. In addition the farmer received the value of home grown farm products.

[11]Machinery expense is operating expense on all machinery, including the farm share of the auto, plus depreciation.

[12]Improvement expense includes maintenance, depreciation and insurance on buildings, fences, drainage systems, etc.

[13]Total expense per tillable acre is total expense per farm, plus a charge for the operator's labor, divided by the number of tillable acres.

ment because no change had been made for the rise in the price of real estate, and the same thing can be said of some of the livestock.

Changes in the relative importance of the various crops were less striking, but at the end of the ten years there was a higher percentage of the land in corn, wheat, oats and barley, and less in sod crops and miscellaneous crops.

CHANGES BY TYPE-OF-FARMING AREAS

Many readers may be more interested in what has happened to this business of farming in their particular part of the state than for the whole state. For such persons, tables comparable to the state average table for each type-of-farming area are presented. It should be kept in mind that the farmers who have kept the records from which these tables were made have not been selected, and the results are not typical of all farms. Also, the farms in one area may be less representative than in other areas. The accompanying map (Fig. 3) shows the counties included in each area. The area tables are presented in numerical order.

Area	Name
1.	Corn and Livestock
2.	Small Grains and Livestock
3.	Southwestern Fruit and Truck Crops
4.	Poultry, Dairy and Truck Crops
5.	Dairy and General Farming
6.	Dairy and Cash Crops
7.	Dairy, Hay, and Special Crops
8.	Beans, Sugar Beets, and Dairy
9.	Cattle, Sheep, and Forage
10.	Central Potato and Dairy
11.	Northern Fruit and Dairy
12.	Northern Potato and Dairy
13.	General, Self-Sufficing, and Part-Time
14.	Cattle, Potatoes, and Self-Sufficing
15.	Cattle, Hay, and Spring Grains
16.	Dairy and Potatoes
17.	Potatoes, Dairy, and Part-Time

Fig. 3. Type of farming areas in Michigan.

TABLE 2—*Averages by type-of-farming areas*
Area 1 (corn and livestock) farm account averages, 1940-49

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	90	90	115	100	97	102	96	95	80	97
SIZE OF BUSINESS										
Total acres per farm	175	183	179	182	195	191	193	196	192	202
Tillable acres per farm	133	139	135	138	149	147	146	151	150	153
Productive days work per farm	511	543	529	531	573	554	594	522	533	544
Productive days work per man	273	292	301	301	333	335	332	330	331	331
Gross income per man	$2,064	$3,010	$3,915	$4,094	$4,662	$5,276	$3,522	$7,222	$7,182	$5,889
Average number of men	1.9	1.9	1.8	1.8	1.7	1.6	1.6	1.6	1.6	1.6
Machinery investment per farm	$1,835	$2,006	$2,205	$2,590	$2,705	$2,922	$3,068	$3,419	$4,049	$5,125
Total farm investment	$16,384	$17,281	$18,249	$20,059	$20,837	$20,620	$22,285	$24,424	$25,740	$27,923
CROPS										
Percent of tillable acres in:										
Sod crops	42	42	38	38	35	34	37	34	31	34
Corn	20	22	24	27	30	27	28	26	28	27
Wheat	10	10	8	8	12	12	10	16	19	15
Oats and barley	14	15	17	13	13	17	18	11	16	19
Soybeans	5	4	7	4	4	4	3	2	1	0
Crop yield index*	111	111	105	103	101	108	113	101	111	106
LIVESTOCK										
Productive animal units	34.5	37.6	34.3	36.0	37.2	34.0	37.5	36.1	29.6	31.6
Tillable acres per P.A.U.	3.8	3.7	3.9	3.8	4.0	4.2	3.9	4.2	5.1	4.9
Dairy product sales per cow	$112	$135	$160	$192	$228	$245	$289	$303	$353	$292
Hog income per litter	82	169	222	181	281	231	306	402	331	229
Sheep income per ewe	20	27	28	28	26	19	21	21	23	25
Egg sales per hen	1.99	2.71	3.55	4.58	4.14	4.92	4.67	5.98	6.85	6.33
INCOME (per farm)										
Crops	$845	$1,134	$1,651	$1,239	$1,612	$2,296	$2,063	$2,813	$2,603	$1,844
Livestock	2,844	4,295	5,062	5,736	6,113	6,133	7,860	8,211	8,602	7,471
Other	170	169	177	231	294	277	227	392	380	369
Gross Income	$3,859	$5,598	$6,890	$7,206	$8,019	$8,706	$10,150	$11,416	$11,585	$9,684
Expense per farm	$1,948	$2,466	$2,922	$3,968	$4,258	$4,243	$4,699	$5,599	$6,339	$6,210
Net Farm Income	1,911	3,132	3,968	3,238	3,761	4,463	5,451	5,817	5,246	3,474
Labor Income	1,092	2,268	3,056	2,235	2,719	3,432	4,337	4,596	3,954	2,079
EXPENSES (per til. acre)										
Man labor (all)	$8.04	$7.96	$11.45	$14.29	$13.64	$13.68	$13.90	$16.02	$16.64	$16.66
Machinery	2.81	3.36	3.76	4.58	5.08	5.52	6.81	9.24	10.61	11.51
Improvements	1.28	1.38	1.53	2.00	2.01	1.91	2.78	2.84	3.06	3.19
Feed bought	3.40	5.54	7.29	10.60	9.88	9.06	8.52	9.77	12.20	9.20
Crops (fert., seed, etc.)	1.70	1.89	2.44	3.20	3.53	4.27	5.36	5.94	6.71	6.30
Taxes on property	.83	.80	.78	.85	.88	.92	.95	1.21	1.14	1.29
Other items	.89	1.05	1.06	1.32	1.28	1.33	1.54	1.65	1.69	2.05
Total	$18.95	$21.98	$28.31	$36.84	$36.30	$36.69	$39.86	$46.67	$52.05	$50.20
Gross income per til. acre	28.98	40.39	50.88	52.10	53.87	59.77	69.50	75.68	77.35	63.12

*Average of all accounting farms each year = 100.

Area 2 (small grains and livestock) farm account averages, 1940-49

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	118	91	91	89	87	75	73	78	73	69
SIZE OF BUSINESS										
Total acres per farm	196	201	187	198	206	207	221	224	232	219
Tillable acres per farm	147	152	144	151	158	161	173	177	184	175
Productive days work per farm	484	503	480	504	521	526	544	545	553	564
Productive days work per man	248	267	273	293	310	324	325	320	327	343
Gross income per man	$1,715	$1,842	$3,290	$3,883	$3,640	$4,512	$5,223	$6,777	$6,505	$6,152
Average number of men	1.9	1.9	1.8	1.7	1.7	1.6	1.7	1.7	1.7	1.6
Machinery investment per farm	$1,544	$1,644	$1,801	$2,091	$2,258	$2,410	$2,879	$3,353	$4,157	$4,594
Total farm investment	$16,386	$16,185	$15,040	$16,501	$17,888	$17,867	$20,602	$22,275	$25,374	$25,559
CROPS										
Percent of tillable acres in:										
Sod crops	45	44	43	43	41	41	41	40	41	42
Corn	17	18	18	20	23	22	24	23	20	21
Wheat	11	11	9	9	12	14	11	17	18	18
Oats and barley	9	10	11	16	12	12	13	12	15	15
Soybeans	3	3	4	2	1	0	0	0	0	0
Crop yield index	98	98	91	106	76	91	96	90	89	93
LIVESTOCK										
Productive animal units	29.0	32.5	28.4	32.6	33.9	32.0	36.7	35.7	31.1	34.0
Tillable acres per P.A.U.	5.1	4.6	5.0	4.6	4.6	5.0	4.7	4.9	5.9	5.1
Dairy product sales per cow	$112	$131	$146	$179	$203	$227	$269	$287	$320	$278
Hog income per litter	77	150	231	177	224	236	283	393	322	231
Sheep income per ewe	10	14	13	11	11	16	18	21	17	23
Egg sales per hen	1.83	2.68	3.67	4.29	4.03	4.96	4.28	6.20	6.73	6.69
INCOME (per farm)										
Crops	$783	$1,073	$1,644	$1,642	$872	$1,663	$1,723	$3,372	$2,100	$2,139
Livestock	2,384	3,463	4,002	4,871	5,052	5,472	6,858	7,886	8,499	7,555
Other	177	191	144	165	192	175	174	284	405	416
Gross Income	$3,344	$4,727	$5,790	$6,678	$6,116	$7,310	$8,755	$11,542	$11,004	$10,110
Expense per farm	$1,846	$2,300	$2,649	$3,380	$3,770	$3,953	$4,555	$6,128	$6,838	$6,672
Net Farm Income	1,498	2,427	3,141	3,298	2,346	3,357	4,200	5,414	4,166	3,438
Labor Income	679	1,618	2,389	2,473	1,452	2,464	3,169	4,300	2,903	2,160
EXPENSES (per til. acre)										
Man labor (all)	$7.23	$7.33	$10.66	$12.49	$12.35	$12.13	$12.00	$14.60	$14.49	$14.42
Machinery	2.36	2.82	3.13	4.09	4.61	4.89	5.76	7.43	8.26	9.45
Improvements	1.25	1.31	1.41	1.67	1.67	1.62	1.92	2.32	2.62	2.88
Feed bought	2.55	4.05	5.54	7.23	7.22	7.39	6.22	10.76	10.55	10.33
Crops (fert., seed, etc.)	1.42	1.61	2.41	3.01	3.38	3.66	4.92	5.62	6.41	6.48
Taxes on property	.75	.76	.70	.66	.70	.73	.86	.93	1.06	1.04
Other items	.86	1.04	.89	1.03	1.24	1.21	1.32	1.50	1.77	2.02
Total	$16.42	$18.92	$24.74	$30.18	$31.17	$31.63	$33.00	$43.16	$45.16	$46.62
Gross income per til. acre	22.67	31.18	40.30	44.26	38.75	45.45	50.46	65.35	59.71	57.74

Area 3 (southwestern fruit and truck crops) farm account averages, 1940-49

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	43	34	36	28	30	25	24	17	23	24
SIZE OF BUSINESS										
Total acres per farm	89	95	107	106	106	111	110	116	106	108
Tillable acres per farm	74	77	88	88	86	91	89	92	86	86
Productive days work per farm (not available)										
Productive days work per man (not available)										
Gross income per man	$1,700	$1,915	$2,915	$4,147	$4,084	$3,724	$4,925	$4,370	$4,087	$3,844
Average number of men	2.6	2.9	2.5	2.6	2.8	2.3	2.8	2.3	2.2	2.5
Machinery investment per farm	$1,775	$1,749	$2,141	$2,541	$2,774	$2.984	$3,249	$3,544	$3,811	$4,518
Total farm investment	$16,852	$16,255	$17,262	$19,684	$21,185	$22,432	$23,264	$23,058	$23,011	$24,298
CROPS										
Percent of tillable acres in:										
Sod crops	29	25	26	23	20	19	24	28	23	21
Corn	10	10	13	16	15	16	12	14	15	12
Wheat	3	4	4	4	4	3	3	3	5	6
Oats and barley	6	5	8	7	6	8	7	8	7	7
Fruit	46	47	39	41	47	43	49	40	42	44
Crop yield index	108	104	90	115	77	103	108	115	110	110
LIVESTOCK										
Productive animal units	9.2	9.6	12.1	13.6	10.6	12.0	10.7	10.4	9.0	9.9
Tillable acres per P.A.U.	5.0	5.1	5.1	6.5	4.6	4.6	4.2	5.3	5.4	4.9
Dairy product sales per cow	$93	$110	$143	$191	$231	$258	$283	$291	$309	$247
Hog income per litter	65	328	200	135	180	300	263	392	256	352
Sheep income per ewe										
Egg sales per hen	2.22	2.70	3.34	3.87	4.28	5.21	4.26	5.73	5.54	6.29
INCOME (per farm)										
Crops	$3,352	$4,245	$5,300	$8,334	$8,864	$6,081	$11,346	$6,824	$4,501	$6,870
Livestock	869	1,162	1,810	2,186	2,149	2,181	2,421	2,875	2,577	2,327
Other	249	146	178	261	219	151	183	339	1,328	412
Gross Income	$4,470	$5,553	$7,288	$10,781	$11,232	$8,713	$13,950	$10,038	$8,406	$9,609
Expense per farm	$2,682	$3,327	$3,788	$5,322	$6,637	$6,157	$8,408	$7,581	$6,656	$8,116
Net Farm Income	1,788	2,226	3,500	5,459	4,595	2,556	5,542	2,457	1,750	1,493
Labor Income	945	1,414	2,637	4,475	3,536	1,434	4,378	1,304	602	279
EXPENSES (per til. acre)										
Man labor (all)	$20.76	$22.65	$26.20	$36.24	$46.39	$36.30	$51.81	$41.74	$41.23	$47.48
Machinery	5.80	6.38	6.09	8.93	10.42	11.37	13.18	14.61	14.54	19.01
Improvements	1.96	1.87	1.94	2.51	3.24	3.62	4.21	5.00	4.04	5.61
Feed bought	3.19	4.49	5.73	8.84	8.67	8.43	7.90	11.39	9.95	9.48
Crops (fert., seed, etc.)	10.06	11.61	10.82	14.02	18.14	16.94	25.51	21.53	20.02	23.16
Taxes on property	1.10	1.17	1.04	1.10	1.17	1.10	1.34	1.95	1.77	1.67
Other items	1.28	1.27	1.25	1.57	2.59	2.34	3.54	2.33	4.50	4.52
Total	$44.15	$49.44	$53.07	$73.21	$90.62	$80.10	$107.49	$98.55	$96.05	$110.93
Gross income per til. acre	60.65	72.12	82.73	123.07	131.18	95.85	157.07	109.22	98.28	112.25

Area 4 (poultry, dairy and truck crops) farm account averages, 1940-49

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	67	55	65	52	49	49	42	45	40	52
SIZE OF BUSINESS										
Total acres per farm	119	136	138	142	151	168	167	156	163	160
Tillable acres per farm	93	106	108	108	117	131	128	120	124	122
Productive days work per farm	476	493	496	519	541	570	556	511	512	527
Productive days work per man	258	265	277	283	296	302	284	289	294	324
Gross income per man	1,772	2,401	3,110	3,517	3,885	4,380	4,796	6,160	6,157	4,787
Average number of men	1.8	1.9	1.8	1.8	1.8	1.9	2.0	1.8	1.7	1.6
Machinery investment per farm	$1,442	$1,646	$1,963	$2,151	$2,272	$2,628	$3,139	$3,497	$4,315	$4,849
Total farm investment	$12,475	$13,140	$13,790	$15,010	$16,045	$17,708	$19,477	$19,686	$22,090	$21,870
CROPS										
Percent of tillable acres in:										
Sod crops	42	43	40	41	38	38	38	39	38	34
Corn	19	16	20	21	22	23	23	21	21	23
Wheat	10	9	9	10	14	12	11	15	18	17
Oats and barley	17	17	18	19	15	18	20	18	17	19
Fruit and truck	3	4	4	2	3	3	3	2	0	0
Crop yield index	105	104	102	110	104	102	98	106	101	102
LIVESTOCK										
Productive animal units	23.7	32.7	25.0	28.4	28.4	29.0	28.7	26.3	25.5	26.5
Tillable acres per P.A.U	3.9	4.4	4.3	3.8	4.0	4.5	4.5	4.6	4.9	4.6
Dairy product sales per cow	$119	$147	$165	$200	$229	$250	$297	$324	$336	$272
Hog income per litter	94	199	252	224	284	209	454	418	343	235
Sheep income per ewe	.....	13	17	14	14	12	18	16	.....	26
Egg sales per hen	2.45	3.06	4.12	4.75	4.64	5.63	5.29	7.29	8.30	7.15
INCOME (per farm)										
Crops	$418	$867	$1,158	$813	$1,108	$1,210	$1,247	$1,830	$905	$1,352
Livestock	2,732	3,386	4,255	5,489	5,804	6,912	8,042	8,666	9,406	7,608
Other	128	213	155	169	198	157	162	404	402	392
Gross Income	$3,278	$4,466	$5,568	$6,471	$7,110	$8,279	$9,451	$10,900	$10,713	$9,352
Expense per farm	$1,785	$2,150	$2,736	$3,619	$3,899	$4,683	$5,466	$6,163	$6,679	$6,331
Net Farm Income	1,493	2,316	2,832	2,852	3,211	3,596	3,985	4,737	4,034	3,021
Labor Income	869	1,659	2,142	2,101	2,409	2,710	3,011	3,753	2,930	1,927
EXPENSES (per til. acre)										
Man labor (all)	$11.00	$10.46	$14.76	$18.79	$18.18	$17.06	$19.06	$22.51	$22.43	$21.06
Machinery	3.39	3.88	4.62	5.43	5.58	6.04	6.92	9.65	10.90	11.41
Improvements	1.56	1.40	1.56	2.01	2.13	2.00	2.44	2.82	3.01	3.36
Feed bought	5.47	6.03	8.22	12.53	11.34	12.62	13.97	19.21	19.46	17.46
Crops (fert., seed, etc.)	1.87	2.13	2.88	3.14	3.72	4.10	6.13	6.26	6.12	6.66
Taxes on property	.79	.86	.84	.84	.97	.92	1.01	1.08	1.17	1.27
Other items	1.32	1.09	1.18	1.49	1.59	1.76	2.14	2.19	2.66	2.83
Total	$25.40	$25.85	$34.06	$44.23	$43.51	$44.50	$51.67	$63.72	$65.75	$64.05
Gross income per til. acre	35.16	42.14	51.48	60.01	61.01	63.43	74.34	90.47	86.13	76.91

Area 5 (dairy and general farming) farm account averages, 1940-49

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	210	157	198	186	167	142	136	149	157	171
SIZE OF BUSINESS										
Total acres per farm	179	191	189	192	202	211	209	215	216	223
Tillable acres per farm	133	139	141	142	153	160	160	162	165	167
Productive days work per farm	487	522	506	509	559	552	552	537	519	580
Productive days work per man	261	281	286	289	320	331	323	319	319	342
Gross income per man	$1,913	$2,737	$3,567	$3,743	$4,151	$4,854	$5,251	$8,520	$4,456	$6,233
Average number of men	1.9	1.9	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7
Machinery investment per farm	$1,735	$2,114	$2,336	$2,477	$2,638	$2,912	$3,112	$3,456	$4,432	$5,708
Total farm investment	$16,441	$17,717	$18,043	$19,092	$20,110	$21,033	$22,192	$23,854	$27,819	$30,444
CROPS										
Percent of tillable acres in:										
Sod crops	42	43	41	42	38	37	38	40	37	41
Corn	18	18	20	19	24	22	23	21	22	22
Wheat	10	9	9	8	13	15	11	16	18	14
Oats and barley	15	16	18	14	13	14	18	12	16	17
White pea beans	4	6	3	5	5	3	3	2	0	0
Crop yield index	102	108	104	100	95	103	95	103	103	106
LIVESTOCK										
Productive animal units	30.2	34.1	31.4	32.6	32.3	31.0	33.2	33.1	29.5	33.8
Tillable acres per P.A.U.	4.4	4.1	4.5	4.3	4.7	5.1	4.8	4.9	5.6	5.0
Dairy product sales per cow	$113	$137	$162	$200	$238	$253	$288	$315	$352	$302
Hog income per litter	89	129	213	167	230	212	291	383	331	223
Sheep income per ewe	12	15	17	12	12	17	25	22	17	22
Egg sales per hen	2.02	2.58	3.47	4.24	3.87	4.86	4.67	6.02	6.03	5.92
INCOME (per farm)										
Crops	$820	$1,158	$1,627	$1,327	$1,584	$1,997	$1,574	$3,077	$1,601	$2,119
Livestock	2,587	3,742	4,506	5,087	5,430	5,880	7,171	8,010	8,236	7,895
Other	171	190	180	173	251	229	226	366	601	554
Gross Income	$3,578	$5,090	$6,313	$6,587	$7,265	$8,106	$8,971	$11,453	$10,438	$10,568
Expense per farm	$1,769	$2,231	$2,648	$3,410	$3,763	$3,827	$4,549	$5,550	$6,033	$6,399
Net Farm Income	1,809	2,859	3,665	3,177	3,502	4,279	4,422	5,903	4,405	4,169
Labor Income	987	1,973	2,763	2,222	2,496	3,228	3,312	4,710	3,014	2,647
EXPENSES (per til. acre)										
Man labor (all)	$7.74	$7.92	$11.01	$13.50	$13.10	$12.41	$12.91	$15.56	$15.79	$15.78
Machinery	2.62	3.27	3.84	4.30	5.00	5.30	6.22	7.97	9.78	10.70
Improvements	1.35	1.42	1.44	1.87	1.94	1.93	2.62	2.76	2.69	3.63
Feed bought	2.58	3.90	4.77	7.23	6.33	5.76	6.68	9.27	8.54	7.53
Crops (fert., seed, etc.)	1.64	1.90	2.50	3.06	3.50	3.57	4.63	5.28	5.75	6.14
Taxes on property	.70	.72	.71	.75	.78	.86	.96	1.08	1.18	1.26
Other items	.86	1.04	.91	1.14	1.34	1.26	1.55	1.59	1.87	2.21
Total	$17.49	$20.17	$25.18	$31.85	$31.99	$31.09	$35.57	$43.51	$45.60	$47.25

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	73	52	52	50	49	44	40	34	33	38
SIZE OF BUSINESS										
Total acres per farm	168	163	167	180	193	209	196	198	216	214
Tillable acres per farm	123	122	125	133	144	156	152	154	173	161
Productive days work per farm	518	493	498	535	577	547	565	536	597	529
Productive days work per man	252	256	263	262	270	253	257	254	279	286
Gross income per man	$1,753	$2,307	$3,573	$3,198	$3,577	$3,932	$4,324	$3,598	$5,624	$5,561
Average number of men	2.1	2.1	1.9	2.4	2.4	2.2	2.2	2.1	2.1	1.8
Machinery investment per farm	$1,679	$1,810	$2,216	$2,608	$2,690	$3,002	$3,193	$3,633	$4,742	$5,575
Total farm investment	$15,870	$15,662	$16,872	$18,938	$19,685	$21,204	$22,450	$24,777	$29,117	$29,113
CROPS										
Percent of tillable acres in:										
Sod crops	46	49	49	51	47	46	45	52	46	41
Corn	17	16	16	16	18	15	17	15	15	17
Wheat	7	6	5	4	7	7	6	9	9	13
Oats and barley	17	16	18	7	14	16	17	10	15	20
Fruit	3	3	4	3	3	4	4	3	1	0
White pea beans	2	3	4	6	6	3	4	3	4	3
Crop yield index	102	100	106	93	96	100	105	108	103	100
LIVESTOCK										
Productive animal units	25.2	26.4	26.2	28.5	31.0	29.0	27.6	28.5	29.7	27.8
Tillable acres per P.A.U.	4.8	4.5	4.7	4.8	4.6	5.4	5.5	5.4	5.8	5.8
Dairy product sales per cow	$124	$149	$189	$220	$251	$280	$301	$321	$330	$329
Hog income per litter	90	168	184	172	276	188	230	247	376	220
Sheep income per ewe	11	14	14	13	10	9	15	.....	10	.....
Egg sales per hen	2.35	2.98	4.08	4.43	4.22	4.63	4.34	6.32	6.63	6.44
INCOME (per farm)										
Crops	$809	$1,346	$2,152	$2,142	$2,447	$2,157	$2,610	$3,061	$2,439	$2,569
Livestock	2,636	3,328	4,459	5,251	5,784	6,176	6,678	7,765	9,377	7,398
Other	166	148	142	155	176	199	222	429	207	322
Gross Income	$3,611	$4,822	$6,753	$7,548	$8,407	$8,532	$9,510	$11,255	$12,023	$10,289
Expense per farm	$1,900	$2,287	$3,054	$4,223	$4,711	$4,665	$5,400	$6,224	$7,525	$6,299
Net Farm Income	1,711	2,535	3,699	3,325	3,696	3,867	4,110	5,031	4,498	3,990
Labor Income	918	1,752	2,856	2,378	2,712	2,807	2,988	3,792	3,042	2,534
EXPENSES (per til. acre)										
Man labor (all)	$9.38	$10.74	$15.70	$19.10	$19.73	$17.41	$19.61	$22.98	$20.58	$17.81
Machinery	3.12	3.92	4.68	5.21	6.00	5.82	6.90	8.59	9.86	10.84
Improvements	1.29	1.42	1.57	1.78	1.91	1.82	2.29	2.98	3.21	3.06
Feed bought	2.22	3.08	4.07	6.54	5.92	5.13	4.79	6.28	7.38	6.38
Crops (fert., seed, etc.)	2.00	2.39	3.90	3.78	4.30	4.28	5.91	5.90	7.49	6.65
Taxes on property	.77	.71	.67	.74	.78	.85	1.10	.93	.97	1.10
Other items	1.20	1.25	1.34	1.66	1.74	1.53	1.78	1.93	2.38	2.57
Total	$19.98	$23.51	$31.93	$38.81	$40.38	$36.84	$42.38	$49.59	$51.87	$48.41
Gross income per til. acre	29.38	39.62	54.19	54.84	58.22	54.55	62.71	73.06	69.67	63.85

Area 7 (dairy, hay, and special crops) farm account averages, 1940-49

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	33	30	32	28	29	29	20	26	31	33
SIZE OF BUSINESS										
Total acres per farm	209	207	211	228	238	219	229	213	204	221
Tillable acres per farm	161	159	163	176	180	170	192	168	162	171
Productive days work per farm	544	540	522	545	571	527	598	519	496	549
Productive days work per man	267	276	281	280	312	297	305	301	281	293
Gross income per man	$1,850	$2,656	$3,270	$3,055	$4,040	$3,885	$4,891	$5,399	$5,691	$5,446
Average number of men	2.0	2.0	1.8	1.9	1.8	1.8	2.0	1.7	1.8	1.9
Machinery investment per farm	$2,121	$2,268	$2,463	$2,817	$2,766	$2,747	$3,141	$3,554	$4,276	$5,972
Total farm investment	$17,226	$17,037	$18,010	$20,063	$20,189	$20,133	$22,897	$23,800	$24,603	$28,094
CROPS										
Percent of tillable acres in:										
Sod crops	42	42	47	58	51	49	53	55	46	44
Corn	8	6	7	7	9	8	8	11	9	8
Wheat	8	7	5	4	6	8	5	10	13	11
Oats and barley	17	19	18	11	15	17	16	4	14	15
White pea beans	14	17	10	12	13	5	9	6	7	10
Sugar beets	5	6	8	3	2	3	5	3	4	3
Crop yield index	106	97	101	70	98	96	104	93	107	108
LIVESTOCK										
Productive animal units	27.0	26.7	26.1	30.6	31.0	31.0	30.3	30.7	26.8	28.9
Tillable acres per P.A.U.	6.0	6.0	6.2	5.8	5.8	5.5	6.3	5.5	6.0	5.9
Dairy product sales per cow	$101	$124	$161	$186	$229	$251	$295	$305	$338	$299
Hog income per litter	82	114	173	115	152	140	272	370	256	100
Sheep income per ewe	9	12	14	8	9	10	13	14	20	18
Egg sales per hen	2.41	2.78	3.44	4.30	3.44	3.54	3.78	4.30	3.85	4.52
INCOME (per farm)										
Crops	$1,119	$1,949	$2,027	$1,038	$2,207	$1,276	$2,781	$1,992	$2,413	$2,766
Livestock	2,509	3,047	3,813	4,707	5,021	5,423	6,512	6,916	7,116	6,909
Other	147	209	209	182	165	216	301	384	494	508
Gross Income	$3,775	$5,205	$6,049	$5,927	$7,393	$6,915	$9,594	$9,292	$10,023	$10,183
Expense per farm	$1,667	$2,027	$2,476	$3,422	$3,631	$3,728	$4,864	$5,402	$5,526	$ 6,235
Net Farm Income	2,108	3,178	3,573	2,505	3,762	3,187	4,730	3,910	4,497	3,948
Labor Income	1,247	2,326	2,673	1,502	2,753	2,181	3,585	2,720	3,267	2,543
EXPENSES (per til. acre)										
Man labor (all)	$6.60	$7.09	$10.05	$11.71	$11.73	$12.57	$12.76	$16.31	$16.96	$16.41
Machinery	2.72	3.29	3.52	4.01	4.44	4.93	5.65	7.49	9.97	11.72
Improvements	.94	1.15	1.02	1.30	1.38	1.47	1.79	2.08	2.56	2.50
Feed bought	.92	1.62	2.21	4.60	4.33	4.75	4.62	8.42	6.06	5.52
Crops (fert., seed, etc.)	1.45	1.79	2.46	2.17	2.51	2.75	3.79	4.20	4.87	5.48
Taxes on property	.55	.55	.56	.64	.73	.71	.98	.73	.92	.97
Other items	.77	.67	.70	1.07	1.17	1.14	1.41	1.60	1.67	2.19
Total	$13.95	$16.16	$20.52	$25.50	$26.29	$28.32	$31.00	$40.83	$43.01	$44.79
Gross income per til. acre	23.44	32.64	37.14	33.69	41.18	40.77	49.86	55.31	61.87	59.41

Area 8 (beans, sugar beets, and dairy) farm account averages, 1940-49

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	121	102	129	120	115	104	91	83	72	75
SIZE OF BUSINESS										
Total acres per farm	146	158	150	175	181	166	169	166	168	163
Tillable acres per farm	112	118	114	132	139	127	132	126	128	124
Productive days work per farm	454	487	480	502	521	492	521	470	479	483
Productive days work per man	247	266	268	274	289	289	285	271	280	288
Gross income per man	$1,810	$2,921	$3,323	$3,709	$4,268	$4,531	$5,423	$6,114	$6,053	$5,781
Average number of men	1.8	1.8	1.8	1.8	1.8	1.7	1.8	1.7	1.7	1.7
Machinery investment per farm	$1,912	$2,188	$2,440	$2,868	$2,974	$2,960	$3,234	$3,432	$4,175	$5,230
Total farm investment	$16,413	$17,148	$18,028	$20,340	$21,128	$21,243	$22,036	$22,716	$24,951	$26,518
CROPS										
Percent of tillable acres in:										
Sod crops	32	32	32	35	28	31	33	33	28	29
Corn	15	14	15	14	16	16	18	16	16	17
Wheat	7	7	6	6	10	10	8	13	16	15
Oats and barley	19	20	20	14	16	18	18	14	8	17
White pea beans	14	17	13	16	17	12	14	15	14	12
Sugar beets	8	6	7	4	6	6	5	3	3	5
Crop yield index	113	116	112	109	116	112	119	116	102	115
LIVESTOCK										
Productive animal units	22.9	25.9	25.4	28.4	28.5	26.0	27.5	24.5	24.0	24.6
Tillable acres per P.A.U.	4.9	4.5	4.5	4.6	4.8	5.0	4.8	5.2	5.4	5.0
Dairy product sales per cow	$93	$127	$148	$184	$210	$235	$278	$294	$326	$283
Hog income per litter	93	172	234	187	239	220	280	462	353	249
Sheep income per ewe	11	14	15	9	10	20	21	22	28	28
Egg sales per hen	2.23	2.86	3.55	4.04	3.54	4.30	3.96	4.98	5.58	5.01
INCOME (per farm)										
Crops	$1,207	$2,186	$2,044	$2,226	$2,921	$2,323	$3,950	$4,111	$3,179	$3,297
Livestock	1,956	2,956	3,728	4,339	4,599	5,203	5,792	6,249	6,791	6,023
Other	167	204	177	222	153	176	186	253	371	362
Gross Income	$3,330	$5,346	$5,949	$6,787	$7,673	$7,702	$9,928	$10,613	$10,341	$9,682
Expense per farm	$1,607	$1,977	$2,505	$3,498	$3,676	$3,662	$4,414	$4,976	$5,316	$5,401
Net Farm Income	1,723	3,369	3,444	3,289	3,997	4,040	5,514	5,637	5,025	4,281
Labor Income	902	2,512	2,543	2,289	2,940	2,978	4,413	4,501	3,777	2,955
EXPENSES (per til. acre)										
Man labor (all)	$9.01	$9.04	$13.18	$14.72	$14.20	$15.20	$16.97	$20.22	$19.81	$20.29
Machinery	3.48	4.43	5.40	6.07	6.56	7.40	8.29	10.43	12.26	13.71
Improvements	1.41	1.44	1.67	1.90	2.29	2.45	2.98	3.15	3.49	3.98
Feed bought	2.04	2.92	4.68	7.76	6.03	6.42	6.23	8.14	7.61	7.43
Crops (fert., seed, etc.)	1.95	2.08	3.06	2.86	3.37	3.64	4.88	5.86	6.48	6.13
Taxes on property	.76	.79	.78	.76	.81	.93	1.07	1.22	1.32	1.41
Other items	.92	.87	1.04	1.15	1.25	1.49	1.58	1.82	1.95	2.34
Total	$19.57	$21.57	$29.81	$35.22	$34.51	$37.53	$42.00	$50.84	$52.92	$55.29
Gross income per til. acre	29.78	45.33	52.12	51.73	55.37	60.73	75.01	84.06	80.48	77.84

Area 9 (cattle, sheep, and forage) farm account averages, 1940-49

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	65	48	46	50	40	38	33	29	36	41
SIZE OF BUSINESS										
Total acres per farm	188	177	196	207	210	203	186	203	203	216
Tillable acres per farm	93	105	106	105	113	105	101	119	115	115
Productive days work per farm	384	420	429	422	442	384	404	436	402	401
Productive days work per man	229	239	252	264	288	257	244	261	265	262
Gross income per man	$1,161	$1,910	$2,419	$2,278	$2,516	$2,846	$3,379	$4,126	$4,370	$3,586
Average number of men	1.7	1.8	1.7	1.6	1.8	1.5	1.7	1.7	1.5	1.5
Machinery investment per farm	$1,242	$1,466	$1,672	$1,685	$1,813	$1,777	$1,931	$2,707	$3,072	$4,080
Total farm investment	$10,064	$11,271	$12,461	$13,222	$13,203	$13,171	$12,445	$17,046	$16,035	$18,482
CROPS										
Percent of tillable acres in:										
Sod crops	55	54	53	54	50	50	51	55	49	54
Corn	15	17	17	13	18	14	14	16	14	14
Wheat	3	3	4	4	7	6	7	8	11	6
Oats and barley	14	15	16	14	13	13	17	11	17	17
White pea beans	5	4	3	6	5	4	6	3	4	2
Crop yield index	87	91	95	88	101	96	95	89	97	87
LIVESTOCK										
Productive animal units	26.0	30.1	29.2	30.0	29.3	27.0	25.6	27.6	25.2	24.6
Tillable acres per P.A.U.	3.6	3.5	3.6	3.5	3.8	3.9	3.9	4.3	4.6	4.7
Dairy product sales per cow	$65	$86	$98	$116	$124	$149	$194	$191	$220	$203
Hog income per litter	74	163	196	191	236	242	300	499	352	263
Sheep income per ewe	7	11	13	9	9	16	15	18	23	32
Egg sales per hen	1.57	2.32	3.14	3.43	3.03	3.97	3.72	4.65	4.71	4.30
INCOME (per farm)										
Crops	$202	$548	$672	$357	$1,298	$400	$1,163	$941	$1,000	$406
Livestock	1,597	2,583	3,228	3,106	3,071	3,714	4,225	5,537	5,217	4,727
Other	151	211	212	182	159	126	206	417	398	351
Gross Income	$1,950	$3,342	$4,112	$3,645	$4,528	$4,240	$5,594	$6,895	$6,615	$5,484
Expense per farm	$1,031	$1,425	$1,853	$2,056	$2,053	$2,070	$2,483	$3,733	$3,331	$3,629
Net Farm Income	919	1,917	2,259	1,589	2,475	2,170	3,111	3,162	3,284	1,855
Labor Income	416	1,354	1,636	926	1,815	1,514	2,489	2,310	2,482	930
EXPENSES (per til. acre)										
Man labor (all)	$8.46	$8.20	$10.98	$13.62	$12.93	$13.72	$16.27	$17.92	$17.47	$17.29
Machinery	2.72	3.41	4.20	4.38	4.39	5.42	6.33	8.78	8.42	10.64
Improvements	1.09	1.11	1.28	1.43	1.37	1.48	1.84	2.42	2.46	2.90
Feed bought	1.43	2.84	4.08	5.24	3.83	3.78	4.08	6.54	5.86	5.06
Crops (fert., seed, etc.)	.97	1.28	2.02	1.84	2.26	2.39	3.68	4.55	3.97	4.44
Taxes on property	.62	.61	.64	.66	.60	.67	.69	.65	.70	.78
Other items	.64	.55	.68	.90	.97	1.06	1.09	1.38	1.51	1.93
Total	$15.93	$18.00	$23.88	$28.07	$26.35	$28.52	$33.98	$42.24	$40.39	$43.04
Gross income per til. acre	20.89	31.92	38.67	34.76	40.10	40.30	55.57	58.02	57.45	47.75

Area 10 (central potato and dairy) farm account averages, 1940-49

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	112	91	89	86	86	75	66	75	65	60
SIZE OF BUSINESS										
Total acres per farm	181	198	202	203	203	208	211	185	198	221
Tillable acres per farm	109	117	120	117	121	125	126	117	125	138
Productive days work per farm	449	480	495	511	522	495	485	414	436	476
Productive days work per man	236	253	252	271	285	286	265	271	265	271
Gross income per man	$1,458	$2,120	$2,739	$2,927	$4,310	$3,805	$4,183	$4,637	$4,917	$4,463
Average number of men	1.9	1.9	2.0	1.9	1.5	1.7	1.8	1.5	1.6	1.7
Machinery investment per farm	$1,356	$1,684	$1,910	$2,118	$2,168	$2,388	$2,805	$2,959	$3,752	$4,853
Total farm investment	$11,137	$12,401	$13,098	$13,657	$14,433	$15,422	$15,822	$15,414	$17,684	$21,715
CROPS										
Percent of tillable acres in:										
Sod crops	51	50	48	52	51	51	51	51	48	49
Corn	14	14	15	14	17	16	16	14	15	14
Wheat	4	4	4	3	4	4	4	7	8	9
Oats and barley	11	13	14	13	12	14	13	11	12	14
Beans	4	5	3	2	1	2	1	2	2	1
Potatoes	4	4	4	5	4	4	5	3	2	2
Crop yield index	96	93	97	98	100	95	92	93	97	94
LIVESTOCK										
Productive animal units	22.7	25.6	25.1	26.7	27.4	25.0	26.1	22.7	22.9	24.7
Tillable acres per P.A.U.	4.8	4.5	4.8	4.4	4.4	5.0	4.8	5.2	5.5	5.6
Dairy product sales per cow	$99	$119	$127	$163	$202	$219	$247	$253	$288	$252
Hog income per litter	92	173	218	174	224	179	281	420	368	315
Sheep income per ewe	8	11	13	6	8	16	19	10	21	.....
Egg sales per hen	1.97	2.89	3.72	4.22	4.39	5.30	5.38	6.31	6.58	5.73
INCOME (per farm)										
Crops	$687	$1,094	$1,842	$1,426	$2,016	$1,478	$1,884	$1,443	$1,603	$1,651
Livestock	1,941	2,739	3,338	3,937	4,420	5,042	5,574	5,311	6,078	5,787
Other	143	195	217	169	159	166	197	342	345	401
Gross Income	$2,771	$4,028	$5,397	$5,532	$6,595	$6,686	$7,655	$7,096	$8,026	$7,839
Expense per farm	$1,442	$1,774	$2,412	$3,145	$3,480	$3,689	$4,379	$3,941	$4,624	$5,190
Net Farm Income	1,329	2,254	2,985	2,387	3,115	2,997	3,276	3,155	3,402	2,649
Labor Income	772	1,639	2,330	1,704	2,393	2,226	2,485	2,384	2,517	1,564
EXPENSES (per til. acre)										
Man labor (all)	$9.29	$8.85	$13.21	$16.72	$17.00	$15.67	$17.39	$18.81	$19.40	$18.58
Machinery	2.97	3.44	4.06	5.12	5.68	6.26	6.81	8.69	10.35	10.23
Improvements	1.13	1.15	1.34	1.74	1.81	1.84	2.28	2.26	2.40	2.68
Feed bought	1.94	3.01	4.15	7.50	7.46	7.91	8.59	8.77	7.66	7.17
Crops (fert., seed, etc.)	1.40	1.76	2.97	3.21	3.61	4.25	5.80	4.90	5.76	6.32
Taxes on property	.63	.65	.64	.65	.67	.67	.67	.71	.71	.79
Other items	.86	.85	.85	1.11	1.34	1.52	1.77	1.48	1.82	2.00
Total	$18.22	$19.71	$27.22	$36.05	$37.57	$38.12	$43.31	$45.62	$48.10	$47.77
Gross income per til. acre	25.51	34.46	45.00	47.16	54.31	53.44	60.88	60.50	64.23	56.68

Area 11 (northern fruit and dairy) farm account averages, 1940-49

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	47	38	42	38	35	38	29	24	27	22
SIZE OF BUSINESS										
Total acres per farm	129	145	152	160	157	172	167	146	170	185
Tillable acres per farm	91	101	104	104	108	115	111	98	116	129
Productive days work per farm (not available)										
Productive days work per man (not available)										
Gross income per man	$1,632	$1,843	$2,014	$3,642	$7,481	$2,727	$2,265	$3,816	$4,737	$4,117
Average number of men	2.6	2.5	2.7	2.5	1.8	3.2	3.4	2.9	3.2	3.3
Machinery investment per farm	$1,727	$1,988	$2,315	$2,592	$3,034	$3,500	$4,110	$4,106	$6,636	$7,309
Total farm investment	$15,007	$16,301	$16,988	$18,437	$20,057	$21,752	$22,316	$22,275	$29,958	$34,533
CROPS										
Percent of tillable acres in:										
Sod crops	35	34	33	34	32	41	34	33	27	28
Corn	8	8	10	10	10	11	10	10	9	7
Wheat	3	3	3	2	3	3	3	5	6	6
Oats and barley	6	7	8	9	6	8	8	6	7	6
Beans	2	3	1	1	0	0	0	0	0	0
Fruit	37	31	33	34	39	36	36	36	44	44
Crop yield index	90	86	94	101	92	92	94	89	98	106
LIVESTOCK										
Productive animal units	11.8	14.4	14.9	16.3	13.5	14.0	13.6	11.2	10.2	11.7
Tillable acres per P.A.U.	5.0	4.8	4.8	6.4	4.4	5.3	8.2	5.6	6.4	6.2
Dairy product sales per cow	$78	$99	$116	$144	$193	$182	$229	$248	$274	$224
Hog income per litter	88	123	195	147				323		189
Sheep income per ewe	9	18	21	11						
Egg sales per hen	2.10	2.87	4.23	4.41	4.05	5.30	5.23	6.74	7.53	6.23
INCOME (per farm)										
Crops	$3,092	$2,960	$5,517	$6,514	$11,171	$5,796	$14,766	$8,060	$10,950	$10,355
Livestock	982	1,492	1,953	2,338	2,265	2,580	2,866	2,794	2,813	2,783
Other	218	228	193	256	254	487	161	358	1,238	578
Gross Income	$4,292	$4,680	$7,663	$9,108	$13,690	$8,863	$17,793	$11,212	$15,001	$13,716
Expense per farm	$2,350	$2,646	$4,008	$4,596	$6,856	$5,110	$9,042	$7,543	$10,182	$10,138
Net Farm Income	1,942	2,031	3,655	4,512	6,831	3,753	8,751	3,669	4,819	3,578
Labor Income	1,192	1,219	2,806	3,590	5,831	2,667	7,635	2,555	3,321	1,851
EXPENSES (per til. acre)										
Man labor (all)	$17.13	$15.39	$24.32	$27.45	$41.23	$24.55	$49.38	$45.53	$47.70	$40.55
Machinery	4.73	5.72	6.59	7.50	9.11	9.26	13.08	14.13	18.46	16.53
Improvements	1.30	1.39	1.61	1.85	2.53	2.24	3.07	3.63	3.10	4.05
Feed bought	1.84	2.38	4.19	6.71	5.39	4.21	5.17	7.55	5.75	5.05
Crops (fert., seed, etc.)	4.60	4.43	6.85	7.88	11.82	10.34	16.32	15.86	18.59	19.17
Taxes on property	.88	.86	.80	.84	.91	.91	1.02	.98	1.58	1.37
Other items	.68	.84	1.10	1.34	1.79	1.64	2.21	2.97	4.84	2.62
Total	$31.16	$31.01	$45.46	$53.57	$72.78	$53.15	$90.25	$90.65	$100.02	$89.34
Gross income per til. acre	47.18	46.29	73.54	87.52	127.35	77.00	159.00	114.41	129.66	106.06

Area 12 (northern potato and dairy) farm account averages, 1940-49

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	121	92	85	89	81	69	52	48	48	54
SIZE OF BUSINESS										
Total acres per farm	188	186	176	194	197	207	203	228	244	234
Tillable acres per farm	101	103	98	108	111	114	122	130	133	134
Productive days work per farm	387	382	369	417	437	416	425	407	417	400
Productive days work per man	212	221	226	235	251	257	264	261	242	242
Gross income per man	$1,194	$1,305	$1,599	$2,242	$2,499	$2,658	$2,817	$3,225	$3,971	$4,008
Average number of men	1.8	1.7	1.6	1.8	1.7	1.6	1.6	1.6	1.7	1.6
Machinery investment per farm	$1,222	$1,376	$1,512	$1,783	$1,926	$2,085	$2,472	$2,756	$3,611	$4,082
Total farm investment	$8,874	$9,302	$9,480	$10,395	$11,069	$11,455	$12,173	$12,612	$14,880	$16,241
CROPS										
Percent of tillable acres in:										
Sod crops	56	56	57	56	56	56	54	54	52	51
Corn	13	11	12	12	14	14	13	11	11	10
Wheat	3	3	3	3	2	2	2	5	3	5
Oats and barley	9	11	11	11	11	12	12	12	14	14
Potatoes	6	6	6	7	7	7	6	6	6	5
Crop yield index	85	73	82	90	89	80	125	77	78	77
LIVESTOCK										
Productive animal units	17.9	18.7	18.4	20.2	21.4	21.0	20.8	20.2	19.6	18.6
Tillable acres per P.A.U.	5.6	5.5	5.3	5.3	5.2	5.5	5.9	6.4	6.8	7.2
Dairy product sales per cow	$86	$91	$111	$136	$162	$167	$200	$199	$229	$199
Hog income per litter	65	141	171	118	203	155	202	295	219	173
Sheep income per ewe	6	9	13	8	6	11	.....	18	11	21
Egg sales per hen	1.59	2.33	2.92	3.15	2.65	3.57	3.76	4.52	4.40	4.03
INCOME (per farm)										
Crops	$525	$946	$1,178	$1,534	$1,888	$1,549	$1,930	$1,444	$2,230	$1,823
Livestock	1,367	1,689	2,221	2,420	2,807	3,102	3,549	3,784	4,201	3,606
Other	152	184	163	188	176	133	167	245	285	264
Gross Income	$2,044	$2,819	$3,562	$4,142	$4,871	$4,784	$5,646	$5,473	$6,716	$5,693
Expense per farm	$1,194	$1,305	$1,599	$2,242	$2,499	$2,658	$2,817	$3,225	$3,971	$4,008
Net Farm Income	850	1,514	1,963	1,900	2,372	2,126	2,829	2,248	2,745	1,685
Labor Income	407	1,049	1,489	1,380	1,819	1,554	2,221	1,617	2,000	873
EXPENSES (per til. acre)										
Man labor (all)	$8.50	$8.40	$11.77	$15.16	$15.30	$14.48	$13.38	$16.00	$17.49	$16.23
Machinery	2.83	2.93	3.42	4.23	5.17	5.68	5.97	6.95	8.42	9.46
Improvements	.89	.98	1.14	1.25	1.50	1.46	1.41	1.44	1.94	1.98
Feed bought	1.53	2.15	3.38	4.41	4.19	4.56	3.89	4.19	4.07	3.89
Crops (fert., seed, etc.)	1.38	1.54	2.25	2.68	3.34	3.51	4.54	4.67	5.61	5.79
Taxes on property	.50	.52	.56	.54	.54	.57	.57	.55	.60	.69
Other items	.65	.63	.69	.82	.95	.99	.95	.99	1.29	1.54
Total	$16.28	$17.15	$23.21	$29.09	$30.99	$31.25	$30.71	$34.79	$39.42	$39.58
Gross income per til. acre	20.23	27.44	36.17	38.42	43.99	42.18	46.25	42.12	50.46	42.61

Area 14 (general, self-sufficing, and part-time) farm account averages, 1940-49

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	39	36	56	50	40	36	33	22	32	54
SIZE OF BUSINESS										
Total acres per farm	207	211	215	208	226	249	234	224	196	186
Tillable acres per farm	97	99	94	98	106	108	114	99	95	92
Productive days work per farm	382	376	342	376	393	376	368	330	311	305
Productive days work per man	212	221	218	232	233	215	220	219	198	210
Gross income per man	$1,143	$1,685	$1,993	$2,162	$2,414	$2,591	$3,140	$3,630	$3,140	$2,946
Average number of men	1.8	1.7	1.6	1.6	1.7	1.7	1.7	1.5	1.6	1.4
Machinery investment per farm	$1,316	$1,688	$1,701	$1,788	$1,649	$1,885	$1,892	$1,987	$2,179	$3,075
Total farm investment	8,786	9,363	9,495	$10,106	$10,533	$11,976	$11,374	$11,626	$12,450	$13,337
CROPS										
Percent tillable acres in:										
Sod crops	55	65	66	65	63	63	65	61	63	55
Corn	7	6	6	6	5	4	4	3	4	5
Wheat	4	3	4	3	2	3	5	9	6	9
Oats and barley	13	12	12	14	12	12	12	12	15	19
Potatoes	4	3	2	3	3	5	3	3	2	2
Crop yield index	87	81	77	93	91	92	92	89	89	83
LIVESTOCK										
Productive animal units	19.8	22.3	22.0	24.7	24.3	23	22.8	21.1	19.0	18.5
Tillable acres per P.A.U.	4.9	4.4	4.3	4.0	4.4	4.8	5.0	4.7	5.0	5.0
Dairy product sales per cow	$70	$94	$109	$123	$137	$156	$188	$190	$216	$158
Hog income per litter	68	158	193	177	225	231	300	353	303	166
Sheep income per ewe	11	11	11	9	9	14	21	19	23	23
Egg sales per hen	1.85	2.50	2.75	3.10	3.31	3.92	3.65	4.16	5.25	4.16
INCOME (per farm)										
Crops	$563	$697	$630	$712	$1,151	$1,249	$1,251	$1,361	$989	$905
Livestock	1,319	1,807	2,307	2,521	2,633	3,042	3,767	3,883	3,763	3,245
Other	175	361	232	269	290	244	238	219	184	133
Gross Income	$2,057	$2,865	$3,169	$3,502	$4,074	$4,535	$5,256	$5,463	$4,936	$4,283
Expense per farm	$1,197	$1,410	$1,441	$1,899	$1,934	$2,324	$2,622	$2,787	$3,081	$2,698
Net Farm Income	860	1,455	1,728	1,603	2,140	2,211	2,634	2,676	1,855	1,585
Labor Income	421	987	1,253	1,098	1,613	1,613	2,066	2,094	1,233	917
EXPENSES (per til. acre)										
Man labor (all)	$8.60	$8.39	$11.69	$11.88	$14.77	$15.70	$14.14	$19.68	$21.69	$20.68
Machinery	3.57	4.16	4.04	4.39	4.23	5.13	5.45	7.40	9.75	9.28
Improvements	.92	1.27	1.05	1.24	1.32	1.74	1.65	2.29	2.36	2.01
Feed bought	1.50	2.63	3.21	5.21	3.19	3.55	4.87	5.15	5.89	5.07
Crops (fert., seed, etc.)	1.32	1.15	1.46	1.65	2.04	2.48	3.01	4.33	4.06	4.18
Taxes on property	.39	.41	.49	.48	.48	.56	.51	.54	.60	.68
Other items	.65	.75	.74	.95	1.04	1.12	1.08	1.20	1.66	1.54
Total	$16.95	$18.76	$22.68	$28.80	$27.07	$30.28	$31.01	$40.59	$46.01	$43.44
Gross income per til. acre	21.19	28.89	33.84	35.90	38.39	41.94	46.16	55.03	51.76	46.46

Area 15 (cattle, hay, and spring grains) farm account averages, 1940-49

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	23	22	22	22	21	25	21	27	52	44
SIZE OF BUSINESS										
Total acres per farm	199	202	207	198	220	208	217	205	185	172
Tillable acres per farm	123	132	128	116	137	130	140	132	123	120
Productive days work per farm	373	370	369	364	391	347	349	316	275	258
Productive days work per man	219	234	239	228	220	222	216	233	211	212
Gross income per man	$1,496	$1,740	$2,058	$1,864	$2,437	$2,710	$3,369	$4,038	$3,332	$2,651
Average number of men	1.7	1.6	1.5	1.6	1.8	1.6	1.6	1.4	1.3	1.2
Machinery investment per farm	$1,206	$1,357	$1,429	$1,611	$1,938	$2,007	$2,169	$2,288	$2,337	$2,695
Total farm investment	$9,712	$9,752	$9,936	$9,889	$11,462	$11,117	$11,467	$11,258	$10,422	$10,650
CROPS										
Percent of tillable acres in:										
Sod crops	62	61	62	63	66	64	60	60	60	59
Corn	1	1	0	0	1	1	1	0	0	0
Wheat	3	3	3	3	5	3	2	5	9	6
Oats and barley	16	21	17	15	12	15	14	16	14	14
Potatoes	1	1	0	1	1	0	0	0	0	0
Crop yield index	96	79	77	77	74	84	104	89	78	81
LIVESTOCK										
Productive animal units	19.3	19.1	17.6	19.0	19.9	17.0	18.6	16.3	11.7	11.7
Tillable acres per P.A.U.	6.4	6.9	7.3	6.1	6.9	7.5	7.5	8.1	10.5	10.2
Dairy product sales per cow	$128	$102	$94	$110	$153	$162	$185	$207	$184	$188
Sheep income per ewe	12	13	14	13	12	15	24	18	27	27
Egg sales per hen	2.74	2.48	3.73	3.92	4.66	5.40	5.54	6.41	6.59	5.90
INCOME (per farm)										
Crops	$330	$693	$718	$470	$1,318	$1,112	$1,558	$1,518	$1,445	$565
Livestock income	1,982	1,722	1,978	2,203	2,716	2,748	3,528	3,552	2,526	2,411
Other	232	334	473	309	303	368	340	409	361	254
Gross Income	$2,544	$2,749	$3,169	$2,982	$4,337	$4,228	$5,426	$5,479	$4,332	$3,230
Expense per farm	$1,248	$1,203	$1,326	$1,818	$2,103	$2,328	$2,586	$2,560	$2,320	$2,121
Net Farm Income	1,296	1,546	1,843	1,164	2,234	1,900	2,840	2,919	2,012	1,109
Labor Income	810	1,058	1,346	670	1,661	1,345	2,267	2,355	1,491	576
EXPENSES (per til. acre)										
Man labor (all)	$6.53	$5.95	$8.29	$12.68	$12.24	$12.09	$11.90	$13.60	$14.16	$13.67
Machinery	2.46	2.38	2.64	3.61	3.74	4.72	4.79	5.52	6.11	6.63
Improvements	.69	.64	.68	1.08	1.18	1.11	1.01	1.34	1.71	1.36
Feed bought	2.13	1.31	2.08	4.02	2.86	3.53	3.69	4.11	3.11	2.80
Crops (fert., seed, etc.)	1.14	1.49	1.34	1.47	1.42	2.20	2.58	2.94	2.99	2.79
Taxes on property	.43	.42	.43	.40	.41	.44	.42	.45	.48	.45
Other items	.48	.37	.46	.73	.64	.88	.86	1.00	.78	.99
Total	13.86	$12.56	$15.92	$23.99	$22.49	$24.97	$25.25	$28.96	$29.34	$28.69
Gross income per til. acre	20.75	20.80	24.70	25.90	31.72	32.46	38.84	41.61	35.09	27.02

Area 16 (dairy and potatoes) farm account averages, 1940-49

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	34	27	26	27	23	23	21	22	19	19
SIZE OF BUSINESS										
Total acres per farm	153	152	175	165	171	185	192	187	175	176
Tillable acres per farm	69	72	88	84	85	86	90	85	78	79
Productive days work per farm	396	410	438	447	454	429	446	452	410	428
Productive days work per man	215	229	249	254	259	251	256	273	253	284
Gross income per man	$1,324	$1,888	$2,333	$2,739	$3,075	$3,181	$3,369	$4,492	$4,598	$4,098
Average number of men	1.8	1.8	1.8	1.8	1.7	1.7	1.6	1.7	1.6	1.5
Machinery investment per farm	$1,529	$1,723	$1,952	$1,922	$2,017	$2,330	$2,561	$2,629	$2,854	$3,920
Total farm investment	$9,418	$9,930	$11,174	$11,313	$12,004	$12,781	$13,504	$13,737	$14,104	$15,682
CROPS										
Percent of tillable acres in:										
Sod crops	56	58	60	60	61	61	60	61	62	64
Corn	11	10	8	10	10	10	11	10	12	14
Wheat	2	1	1	1	1	2	2	2	0	1
Oats and barley	21	21	21	19	20	19	20	20	20	20
Potatoes	6	6	4	4	4	4	4	3	1	1
Crop yield index	107	104	101	116	108	109	120	127	96	110
LIVESTOCK										
Productive animal units	18.8	19.8	22.2	23.2	24.1	24.0	24.3	24.4	22.6	23.7
Tillable acres per P.A.U.	3.7	3.6	4.0	3.6	3.5	3.6	3.7	3.5	3.5	3.3
Dairy product sales per cow	$104	$152	$155	$188	$207	$228	$288	$286	$345	$255
Sheep income per ewe				15	11	14	24	15	13	26
Egg sales per hen	2.40	3.34	3.48	4.21	3.93	4.52	4.52	5.09	4.75	4.59
INCOME (per farm)										
Crops	$456	$421	$578	$765	$890	$752	$873	$967	$173	$201
Livestock	1,803	2,740	3,262	3,635	4,304	4,499	5,846	6,108	6,821	5,578
Other	190	218	266	420	198	189	198	368	459	389
Gross Income	$2,449	$3,379	$4,106	$4,820	$5,392	$5,440	$6,917	$7,443	$7,453	$6,168
Expense per farm	$1,363	$1,561	$1,946	$2,571	$2,942	$3,036	$3,288	$3,706	$3,788	$3,759
Net Farm Income	1,086	1,818	2,160	2,249	2,450	2,404	3,629	3,737	3,665	2,409
Labor Income	615	1,322	1,601	1,683	1,850	1,766	2,954	3,050	2,960	1,625
EXPENSES (per til. acre)										
Man labor (all)	$12.39	$12.10	$14.12	$19.90	$21.19	$20.24	$20.98	$26.63	$25.72	$25.18
Machinery	4.14	5.22	4.78	5.97	6.95	8.18	8.27	10.72	11.57	13.02
Improvements	1.39	1.29	1.31	1.83	2.22	2.07	2.15	2.81	3.45	3.43
Feed bought	4.07	5.07	5.51	8.87	9.05	8.82	8.97	11.18	15.30	12.93
Crops (fert., seed, etc.)	2.43	2.31	2.68	3.26	3.98	4.49	4.11	4.63	5.58	5.22
Taxes on property	.69	.68	.63	.64	.74	.83	.84	.89	.90	.91
Other items	1.32	1.32	1.05	1.25	1.64	1.66	2.14	2.06	2.48	3.04
Total	$26.43	$27.99	$30.11	$41.72	$45.77	$46.29	$47.46	$58.92	$65.00	$63.73
Gross income per til. acre	35.37	46.67	46.82	57.51	63.58	63.25	77.28	87.56	95.16	78.00

Area 17 (potatoes, dairy, and part-time) farm account averages, 1940-49

Year	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Number of farms	67	76	76	82	82	65	61	56	58	59
SIZE OF BUSINESS										
Total acres per farm	158	141	152	168	192	185	184	153	165	166
Tillable acres per farm	56	58	57	69	76	69	66	63	69	70
Productive days work per farm	339	341	351	392	379	365	358	323	320	301
Productive days work per man	192	178	194	215	215	206	209	211	199	199
Gross income per man	$1,042	$1,445	$1,856	$2,147	$2,586	$2,733	$3,182	$3,239	$3,336	$2,582
Average number of men	1.8	1.9	1.8	1.8	1.8	1.8	1.7	1.5	1.6	1.5
Machinery investment per farm	$1,304	$1,335	$1,520	$1,605	$1,802	$1,870	$2,067	$2,059	$2,645	$3,198
Total farm investment	$7,816	$6,959	$7,708	$8,731	$9,523	$9,335	$9,455	$9,211	$9,954	$11,639
CROPS										
Percent of tillable acres in:										
Sod crops	66	67	66	63	66	67	67	67	69	71
Corn	3	1	2	0	1	1	1	0	0	0
Wheat	0	1	1	0	0	1	1	1	1	1
Oats and barley	18	17	20	17	16	19	19	20	20	18
Potatoes	7	6	5	7	5	6	4	3	4	4
Crop yield index	93	96	98	108	93	101	117	116	91	89
LIVESTOCK										
Productive animal units	17.8	16.7	19.1	21.0	20.5	20	19.0	17.4	16.4	16.0
Tillable acres per P.A.U.	3.2	3.5	3.0	3.3	3.7	3.4	3.5	3.6	4.2	4.4
Dairy product sales per cow	$89	$122	$137	$170	$205	$216	$265	$244	$271	$212
Egg sales per hen	2.12	3.70	3.15	3.40	3.30	4.58	5.00	6.25	6.18	5.02
INCOME (per farm)										
Crops	$346	$649	$709	$706	$1,014	$898	$785	$644	$914	$376
Livestock	1,294	1,869	2,420	2,865	3,308	3,701	4,276	3,810	3,957	3,141
Other	194	257	231	336	230	238	397	499	479	394
Gross Income	$1,834	$2,775	$3,360	$3,907	$4,552	$4,837	$5,458	$4,953	$5,350	$3,911
Expense per farm	$1,194	$1,436	$1,782	$2,390	$2,525	$2,718	$2,629	$2,825	$3,195	$3,020
Net Farm Income	640	1,339	1,578	1,517	2,027	2,119	2,829	2,128	2,155	891
Labor Income	249	991	1,193	1,080	1,551	1,653	2,357	1,668	1,657	309
EXPENSES (per til. acre)										
Man labor (all)	$14.24	$15.80	$21.23	$23.55	$21.79	$24.62	$25.43	$31.18	$30.80	$28.85
Machinery	5.25	5.55	6.59	7.05	7.29	8.37	8.06	19.14	10.93	12.41
Improvements	1.53	1.42	1.74	1.81	1.66	1.93	2.30	2.59	3.00	2.90
Feed bought	4.43	5.89	8.48	9.42	8.64	10.85	10.40	12.08	11.64	8.96
Crops (fert., seed, etc.)	2.10	2.53	2.99	3.03	2.92	4.05	4.32	4.90	5.04	5.00
Taxes on property	.55	.45	.57	.55	.50	.56	.59	.63	.69	.68
Other items	.96	.84	1.24	1.05	1.00	1.52	1.66	2.01	2.12	2.31
Total	$29.06	$32.48	$42.84	$46.46	$43.80	$51.90	$52.76	$63.53	$64.22	$61.11
Gross income per til. acre	32.68	47.52	59.07	56.76	59.91	70.42	82.09	78.15	77.29	56.16

IN SUPPORT OF THE BARN OWL

By GEORGE J. WALLACE
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FROM THE many studies on the food habits of birds, it has long been known, among ornithologists at least, that hawks and owls play an important role in the campaign against rodent pests, the hawks working chiefly by day and the owls by night. In spite of the evidence, however, laymen – particularly farmers and sportsmen – have been slow to accept the facts. The former have long retained the usually groundless apprehension that all hawks and owls are a menace to poultry and the latter have held the largely unsupported belief that predatory birds endanger game populations. Owls, in addition, are often regarded as of evil omen, perhaps ever since the elder Pliny was credited with writing "the scritch-owle—is most execrable and accursed" and "if seene—in any place—prognosticates some fearful misfortune."

Thus, our predatory birds, some of which are among the farmer's most useful allies, have been maligned and persecuted for centuries. From the conservation viewpoint the situation has some unfortunate complications. There are many species of hawks and owls—about 400 in fact the world over, not including the hundreds of subspecies. At least 20 species breed in Michigan; more than 50 have been recorded in North America. Each species has different habits, and the habits of a single species may vary widely from place to place or from season to season. Though the general trend in the food habits of most North American species is decidedly on the positive side of the ledger, some have habits that are open to question, and even among the beneficial kinds there are occasional "outlaw" individuals which go astray. The picture is further complicated, from the management standpoint, by difficulties in identification. Few field men can identify hawks and owls accurately, either in the field or on a museum pedestal, so that would-be control measures, with or without legislative approval, are often misdirected.

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Moreover, though the general trends in the diet of most species are fairly well known, we need more exact data on regional and seasonal variations. Stomach analyses in Washington, D. C., for instance, may not accurately portray the role of a marsh hawk in Georgia or Michigan; nor is the winter diet of a great horned owl in an overpopulated pheasant area a true reflection of its summer prey at the peak of the rabbit cycle.

In Michigan, studies on the barn owl appear to show somewhat conclusively what it eats all seasons. A 3-year study recently carried out at East Lansing from 1945 through 1947 covered all seasons and included both a high and a low phase in the meadow mouse cycle *(Microtus)*. The results of that research have been published in a bulletin (Technical Bulletin 208, *The Barn Owl in Michigan)* of the Michigan Agricultural Experiment Station; the following account is a non-technical simplification of the more detailed paper.

THE DISTRIBUTIONAL PICTURE

The barn owl is severely restricted in its distribution in the northern states. A southern species, with its 34 geographic races widely distributed in temperate and tropical regions throughout the world, it occupies a precarious position along the northern boundaries of its range and fluctuates markedly, probably in response both to climatic severity and to the cyclic nature of its prey. In Michigan, it occurs mainly in the southern four tiers of counties, where it is an irregular permanent resident, nesting nearly throughout the year, the adults at least remaining over winter at or near the nesting site. We do not have a full picture of its distribution, however, as the prevalent practice of uninformed hunters and farmers in ridding their premises of owls interferes with the natural distributional pattern. Collected specimens often become mantel pieces without reliable data as to their time and place of capture, and the secretive nocturnal habits of the birds, perhaps fortunately, permit them to go largely undetected in many communities.

SOME BARN-OWL FAMILY HISTORY

Short-term food-habits studies are sometimes justly censured for not providing a true criterion of the actual prey consumed. Mindful of this criticism the author observed the barn owls inhabiting a loft of an unused barn closely for a year and made a month-to-month

TABLE 1—*Monthly trends in one year's prey of the barn owl, July 1945 to June 1946*

Prey animals	July-Sept. 64 pellets 2 adults and 7 young*	October 126 pellets 2 adults and 5-7 young	November 145 pellets 4-5 owls	December 60 pellets 2-5 owls	January 28 pellets 1-2 owls	February 40 pellets 1-2 owls	March 32 pellets incubating female	April 120 pellets female and 4 young	May 84 pellets female and 3-4 young	June 6 pellets nest litter (100± pellets)	Totals 805 pellets
Microtus	160 (92.0%)	328 (92.4%)	422 (90.2%)	143 (88.3%)	63 (96.9%)	68 (89.5%)	47 (94.0%)	260 (95.2%)	268 (94.4%)	337 (93.6%)	2096 (92.5%)
Peromyscus	6 (3.4%)	6 (1.7%)	7 (1.5%)	5 (3.1%)	1 (1.5%)	2 (2.6%)	3 (6.0%)	5 (1.8%)	7 (2.5%)	6 (1.7%)	48 (2.1%)
Synaptomys	... ...	... ...	4 (0.8%)	1 (0.6%)	... ...	... ...	... ...	3 (1.1%)	1 (0.4%)	1 (0.3%)	10 (0.4%)
Mus	... ...	4 (1.1%)	1 (0.2%)	... ...	... ...	... ...	... ...	1 (0.4%)	... ...	... ...	6 (0.3%)
Zapus	3 (1.7%)	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...	1 (0.3%)	4 (0.2%)
Total mice	169 (97.1%)	338 (95.2%)	434 (92.7%)	149 (92.0%)	64 (98.4%)	70 (92.1%)	50 (100%)	269 (98.5%)	276 (97.3%)	345 (95.9%)	2164 (95.5%)
Rattus	1 (0.6%)	2 (0.6%)	1 (0.2%)	... ...	... ...	1 (1.3%)	... ...	1 (0.4%)	... ...	... ...	6 (0.3%)
Blarina	2 (1.1%)	14† (3.9%)	33 (7.1%)	8 (4.9%)	1 (1.5%)	4 (5.3%)	... ...	3 (1.1%)	8 (2.8%)	15 (4.2%)	88 (3.9%)
Cryptotis	... ...	1 (0.3%)	... ...	1 (0.6%)	... ...	... ...	... ...	... ...	... ...	... ...	2 (0.1%)
Birds‡	2 (1.1%)	... ...	... ...	4 (2.5%)	... ...	1 (1.3%)	... ...	... ...	... ...	... ...	7 (0.3%)
Total prey	174 (100%)	355 (100%)	468 (100%)	162 (100%)	65 (100%)	76 (100%)	50 (100%)	273 (100%)	284 (100%)	360 (100%)	2267 (100%)

*Mainly from adults, young not contributing much till late September.
†All but 2 or 3 taken *after* October 22.
‡2 English sparrows, parts of 2 starlings, pieces of 2 pigeon squabs, and 1 song sparrow.

(Table 4, Michigan Agricultural Experiment Station Technical Bulletin 208 (1949), page 35.)

analysis of their prey. After raising a brood of seven in the spring of 1945, the owls reoccupied the nesting box in mid-July and reared a fall brood, remained over winter and renested in March. The barn was visited periodically from July 1945 to June 1946 and a careful record of pellets and prey obtained. Table 1 presents the results: the monthly trends in prey, the number of pellets on which the observed trends are based, the probable numbers of owls producing the pellets each month, and the total prey animals and percentages. This year of observation coincided with the high phase of the *Microtus* (meadow mouse) cycle, so that the take of this one species was particularly high (92.5 percent). Other species of mice added only 3 percent, for a total of 95.5 percent. Mice so predominated in the diet that for no month did the percentage drop below 92, and for one month (March) it was 100 percent. Shrews (88 *Blarina* and 2 *Cryptotis*, totaling 4 percent) were the only other significant mammalian items at this station. Only 7 birds (0.3 percent) were taken—2 English sparrows, 2 starlings, 2 pigeon squabs and 1 song sparrow.

A feature of considerable interest, not shown in the table, was the owl's habit of taking food in excess of immediate needs when the supply was abundant and storing up or discarding the surplus items at or near the nest. During the fall 1945 nesting, there was an accumulation of 189 dead mice (186 meadow mice, 1 deer mouse, 1 house mouse, and 1 unidentified mouse) and one short-tailed shrew on the floor near the nest box. The mouse carcasses, littering perhaps 50 square feet of floor space, had apparently been brought in and drop-

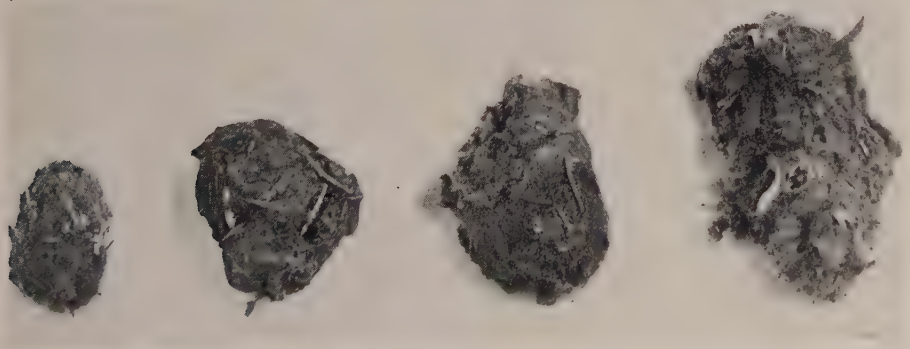

Fig. 1. Four barn-owl pellets, the largest containing the regurgitated fur and skeletal remains of four mice; the smallest probably includes only one mouse. Barn owls periodically (at least once daily) cast up pellets containing the bones and fur of their prey at their roosts and nest sites, where the pellets can be collected for study.

ped. The most apparent explanation for this phenomenon is that the male, or non-incubating bird, accumulated the stock pile during the incubation period in late July and August, and never had occasion to utilize it further.

The mouse-hoarding habit continued in the spring. On March 2 an owl was flushed from the nest box, which contained one egg and 13 mice conveniently cached in the nest box around the egg. Five days later there were 4 eggs and 64 mice, and still later, 80 mice and 6 eggs. By March 23 the whole supply had vanished, either having

Fig. 2. The largest pellet shown in figure 1 was dissected and found to contain the skulls and paired bones (humeri, femora, pelvic bones and tibiae) of four mice. One humerus is missing. The largest pellet examined by the author contained seven mice and one shrew.

been consumed or carried away before the eggs hatched. A further accumulation of mice accompanied hatching, up to a maximum of 73 on April 13 when there were 4 young in the nest. These soon declined and thereafter, with the young growing larger and more voracious, there were no surplus mice left lying around.

This detailed study of a barn-owl family, which raised three broods totaling 17 successfully fledged young in 1945 and 1946, was brought to an unfortunate termination when a nearby resident shot the incubating female (on her fourth clutch of eggs), ostensibly to protect the pigeons with which the owls had lived in apparent harmony for years. (The two pigeon squabs listed in the prey were only partially eaten and may have been carrion.) Studies were continued at other nearby stations to complete the 3-year picture, during which a decline in *Microtus* populations took place and was reflected in the decreased take of this species toward the end of the cycle.

THE 3-YEAR PICTURE

Table 2 gives the combined results of the various collections made at East Lansing over a 3-year period. In 2,200 pellets, gathered from roosts on the campus and from the previously mentioned barn, 6,815 animals were identified. The accompanying table gives the numbers and percentages of each species eaten by the owls. Notable items in the table are that 98.93 percent of the prey was of small mammals, that 91.59 percent was of mice, and that 84.97 percent was of one species, the common meadow mouse *(Microtus pennsylvanicus)*. No poultry or game bird was found among the prey items, and only 1.07 percent was of birds. Most of these (67 out of 73, or 91.7 percent) were English sparrows (50), starlings (15) and pigeons (2). Only 6 (0.08 percent of the total prey) were native song birds—a song sparrow, 2 Savannah sparrows, and 3 unidentified. This is sharply contrary to the widely held impression of the relationship between owls in general and birds. Obviously, at least the barn owls at East Lansing are predominantly mousers at all times. Similar studies at Ann Arbor, on a smaller scale, gave similar results (Wilson, 1938; Moore, 1945); extensive analyses of pellets in Ohio, at Columbus and elsewhere, also closely parallel these figures (Stupka, 1931). Prey items change considerably in the southern and western states, but the diet, with rare exceptions, is still mainly of destructive rodents.

The one questionable item in the barn-owl diet is the considerable take of shrews, which are insectivorous and thus considered beneficial

TABLE 2—*Barn owl prey at East Lansing, Michigan, 1945-47*

Prey animals	Campus		Farm		Total	
	Number	Percent	Number	Percent	Number	Percent
Microtus	2,970	81.26	2,821	89.27	5,791	84.97
Peromyscus	197	5.39	111	3.51	308	4.52
Zapus	57	1.56	23	0.73	80	1.17
Mus	24	0.66	13	0.41	37	0.54
Synaptomys	9	0.24	14	0.44	23	0.34
Unidentified	3	0.08	—	—	3	0.04
Total mice	3,260	89.19	2,982	94.37	6,242	91.59
Blarina	312	8.56	133	4.21	445	6.53
Sorex	21	0.57	7	0.22	28	0.41
Cryptotis	2	0.05	2	0.06	4	0.06
Rattus	8	0.22	7	0.22	15	0.22
Condylura	2	0.05	2	0.06	4	0.06
Scalopus	2	0.05	—	—	2	0.03
Mustela	1	0.03	—	—	1	0.01
Sylvilagus	1	0.03	—	—	1	0.01
Total mammals	3,609	98.74	3,133	99.15	6,742	98.93
Birds	46	1.26	27	0.85	73	1.07
Total prey	3,655	—	3,160	—	6,815	—

animals. Of the 6,815 prey items identified, 477 or 7.10 percent were shrews, mostly the short-tailed shrew, *Blarina brevicauda kirtlandi*. In times of *Microtus* scarcity, shrews increase in the diet. At two Ohio stations (Price, 1942), in Texas (Davis, 1938), and particularly in Europe (many authorities), shrews have been recorded as playing a much more prominent role than they do in Michigan.

Fig. 3. Some skulls recovered from barn-owl pellets. Left to right: starling, English sparrow, meadow mouse, prairie deer mouse, short-tailed shrew and masked shrew.

Ever since A. K. Fisher's classic studies of the barn owls inhabiting the Smithsonian Tower in Washington, barn owls have been popularly supposed to live on rats and mice. However, only 15 rats (0.22 percent) were taken during the period of study covered by this paper, and these were mainly young animals. Rats inhabited poultry houses

Fig. 4. Meadow-mouse skulls taken from pellets collected under a barn owl roost on the Michigan State College campus.

beside the barn occupied by the owls, but the birds apparently went farther afield for their prey. Captive barn owls seemed unable, or at least reluctant, to handle full-grown live white rats, and had obvious difficulty dissecting the tough rodents. One owl worked for two hours beheading a large specimen that had been killed for him. Rats were absent in the Ann Arbor studies mentioned above, and were decidedly minor items in Ohio (0.68 to 1.62 percent at three stations) and in Wisconsin (0.9 percent—Errington, 1931), but in the southern states cotton rats and rice rats may figure more prominently in the diet, even becoming a leading or staple item in some cases (Baumgartner and Baumgartner, 1944).

CONSERVATION AND LEGISLATION

From this account it is clear that as far as Michigan is concerned (and the situation is the same or similar in all northern states), barn owls are not only harmless, but also have an almost faultless economic record, with more than 90 percent (sometimes nearly 100 percent) of their diet composed of injurious or undesirable animals. It seems unfortunate, then, that barn owls are accorded no legal protection in Michigan, and by many are regarded as vermin to be shot. A wiser Australian government seeks to encourage its barn owls, and imposes a $25 fine for the killing of one. The problem of legislative protection of birds of prey, however, involves more issues than the economic. It involves being able to distinguish the different species, which according to actual tests most sportsmen are not able to do. The barn owl, however, is perhaps the most easily identified of the Michigan owls, and is also probably the champion mouser, so that proper legislation supported by an adequate educational campaign might well be effective.

Similarly detailed studies of other Michigan owls have not been made, but it is known in a general way that the barred, long-eared and short-eared owls are likewise predominantly mousers. The smaller owls—the saw-whet, Richardson's and screech owl—also appear to be efficient mousers, although the screech owl is partly insectiverous and at times includes small song birds in its diet. The great horned owl, which is the only large owl of regular occurence in Michigan (the snowy owl is a cyclic invader, the great gray owl is even less known), adds rabbits, poultry and game birds to its rodent prey. Thus, of the owls, only the great horned owl need cause any concern to rabbit hunters, game bird enthusiasts, and poultrymen. The rest, particularly the barn owl, are efficient allies of the farmer. It seems a sad commentary on the affairs of state that at least the barn owl—with its interesting habits, its nearly faultless economic records, and its close association with man—is given no legal protection in Michigan.

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EFFECT OF RATE OF APPLICATION OF FERTILIZER AND SPACING OF PLANTS ON THE PERFORMANCE OF CORNELL 19 AND UTAH 15 CELERY VARIETIES

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AN INCREASE in stalk size of celery produced in Michigan, especially in the green (Pascal-type) would be highly desirable to meet market demand. In general, within limits, the size of plant becomes larger with a wider row spacing or with wider spacing between plants in the row. Higher crop yields generally follow the application of increasing amounts of fertilizer up to a certain point with the greatest response obtained with the first increments of added fertilizer. A part of this increase in yield due to fertilizer can be accounted for in greater weight per plant.

Data based on one year's results reported by Wittwer, Davis, and Reath (2) indicated that larger stalks of green celery were produced in 32-inch rows with a 9-inch spacing than with a 6-inch spacing although the yields were significantly lower and accompanied by a higher percentage of trim. Unpublished data by Harmer and Davis (1) in 1948 showed that with a 28-inch row spacing approximately 10 percent higher yield was obtained with a 6-inch row spacing than with a 4-inch spacing.

This report presents the results of two years' work investigating the effect of rate of fertilizer and spacing of plants on the yield, percentage trim, and size of stalk of Cornell 19 and Utah 15 varieties.

These experiments were located at the Michigan State College Muck Experimental Farm. Two rates of 0-10-30 fertilizer, 1,500 and 2,500 pounds per acre, were applied. In both instances 1,500 pounds were applied with a grain drill before setting the plants and in one case an additional 1,000 pounds was applied as a side-dressing approximately 5 weeks after the plants were set. A uniform application of 500 pounds of salt per acre was applied in 1949 and 250 pounds per acre in 1950. Four row-spacings, 4, 6, and 8, and 10 inches, were util-

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ized in 1949 and three spacings, 4, 6, and 8 inches in 1950. The yields from the 10-inch-spaced plots were so low in 1949 that this treatment was not included in the 1950 work. The plants were set in the field June 1 in 1949 and on June 15 in 1950. The plants were dusted at 7-day intervals with a tri-basic copper fungicide at the rate of 35-50 pounds per acre. Thirty pounds of nitrogen per acre was applied as a side-dressing in addition to the 0-10-30 (150 pounds of ammonium sulfate in 1949 and 100 pounds of ammonium nitrate in 1950). The treatments were arranged in a split-plot design and replicated four times. In both years experiments were harvested during the second and third weeks of September.

The total yields, percentage trim and weights per stalk (trimmed and untrimmed) are presented in Table 1. Significant differences

TABLE 1—*The effect of rate of application of fertilizer and spacing of plants on the performance of Cornell 19 and Utah 15 varieties of celery**

Variety	Pounds 0-10-30 per acre	Spacing (In.)	Tons per acre (Untrimmed)		Pounds per stalk (Untrimmed)		Percent marketable weight		Marketable weight per stalk 1950
			1949	1950	1949	1950	1949	1950	
Cornell 19	1,500	4	45.6	52.2	2.67	2.31	.....	66.2	1.53
		6	33.7	42.0	2.87	2.49	.....	58.1	1.45
		8	31.0	34.0	3.06	2.94	.....	57.4	1.69
		10	28.4	.....	3.48	.....	.....	.....	.....
	2,500	4	51.1	54.3	3.00	2.45	56.1	67.6	1.66
		6	42.4	43.9	3.31	2.58	49.5	59.9	1.55
		8	36.2	40.3	3.74	3.16	48.9	58.8	1.86
		10	34.6	.....	4.09	.....	45.0	.....	.....
Utah 15	1,500	4	48.4	55.2	2.58	2.52	.....	77.1	1.94
		6	37.4	45.9	3.18	2.78	.....	73.9	2.06
		8	31.6	40.6	3.46	3.52	.....	72.6	2.56
		10	29.5	.....	3.83	.....	.....	.....	.....
	2,500	4	54.4	56.7	2.79	2.55	58.7	74.9	1.91
		6	43.0	52.1	3.18	3.19	55.6	71.1	2.27
		8	35.9	46.0	3.70	3.67	57.0	66.6	2.44
		10	33.6	.....	4.48	.....	40.9	.....	.....

*The yield data have been statistically analysed and significant differences (1% level) obtained for rates of fertilizer application and spacing in 1949 and for spacing in 1950. A (5%) level of significance for rates was obtained in 1950.

		1949	1950
L.S.D. between spacings.....	5% level	4.0	3.5
	1% level	5.3	4.8
L.S.D. between rates.....	5% level	3.2	3.3
	1% level	4.8	...

in yield at the 1-percent level were obtained between rates of application and spacing. The plots receiving the 2,500 pounds of fertilizer out-yielded the 1,500-pound treated plots. The average increase for all spacings due to the additional 1,000 pounds of fertilizer was 5.7 and 4.0 tons per acre for 1949 and 1950, respectively. Furthermore, higher yields were obtained from the 4-inch spacing than from the

other spacings. The percent of marketable celery was considerably higher with the 4-inch spacing than with wider spacing. While the size of stalk of untrimmed celery was higher with the wider spacing, this difference in percentage of marketable celery did not always mean a heavier marketable stalk. For example, the average marketable weight of stalk for the Cornell 19 in 1950 from the 4-inch-spaced plots was actually greater than that of celery produced on the 6-inch-spaced areas.

Fig. 1. Stalk of Utah 15, 8-inch spacing. Note excessive amount of laterals (suckers).

It has been repeatedly observed that as the spacing between celery plants increases the growth habit of the plant becomes more decumbent or bushy (Figs. 1 and 2). More lateral growth (suckers) is also associated with this factor of wider spacing, a fact borne out by the greater percentage of trim.

Owing to unfavorable weather conditions (frost, dry weather and wind damage) experienced after setting the plants in 1949, stands were reduced, thus accounting for the higher average weight per

Fig. 2. Comparative size of Utah 15 stalks with 4- and 6-inch spacings in the row. The "6-inch" stalk in this case is rather loose in appearance.

stalk during this season than in 1950. Excellent stands were obtained in 1950 with the aid of overhead irrigation.

SUMMARY

Yields of celery produced on plots receiving 2,500 pounds of 0-10-30 per acre ranged from 4 to 5.7 tons per acre higher than plot yields on which 1,500 pounds per acre were applied.

Lower yields and higher percentage of trim are associated with wider spacings. In general, the weight per stalk increased with wider spacings and with increased rate of fertilizer within the limits of this experiment.

The recommended spacing for any individual grower would depend in part on his marketing procedures. If his outlet is for processing celery, obviously the closer spacing would be best. However, if sufficient premium can be obtained for the heavier stalks to warrant

sacrificing some yield due to the wider spacing, then this would be the procedure to follow.

It should be pointed out that the foregoing data are limited to the two varieties mentioned and to varieties with similar responses. It is entirely possible that a variety could be developed that would stand a wider row spacing without the accompanying reduction in yield and increase in percentage of trim.

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EFFECT OF DEFOLIATION UPON THE GROWTH OF ASPEN

By ROBERT E. DILS and MAURICE W. DAY
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DURING JUNE 1950, a large portion of the aspen-birch forest type on the Dunbar Forest, Chippewa County, Michigan, was subjected to an infestation by the forest tent caterpillar, *Malacosoma disstria* Hubn. Similar attacks were reported in a number of other areas in the eastern end of the upper peninsula of Michigan. To study the effects of the defoliation caused by this infestation, a dendrometer growth study was initiated in the Dunbar Forest Experiment Station.

Defoliation was first observed on or about June 6, 1950. Most of the aspen was completely defoliated by June 12. Nearly all of the aspen-birch type on the forest had been subjected to the attack by June 20. The pupation period of the caterpillar appeared to start about June 25 although insects in the larval stage were observed as late as August 5. After July 1, however, there was little further defoliation. A large percentage of the pupae examined appeared to have been parasitized; however, great numbers of adults began emerging about July 24.

According to Professor W. F. Morofsky, Department of Entomology, Michigan State College, the years 1949, 1950 and 1951 mark the peak of the forest tent caterpillar cycle. This, combined with apparently optimum climatic conditions, caused the outbreak.

The insect appeared to be rather selective, preferring aspen, *Populus tremuloides* Michx., followed by white birch, *Betula papyrifera* Marsh., red oak, *Quercus borealis* Michx., mountain ash, *Sorbus americana* Marsh., hazel-nut, *Corylus cornuta* Marsh., alder, *Ulnus incana* Willd., and elm, *Ulmus americana L.* In addition, large quantities of blueberry, *Vaccinium spp.*, and shrubby willow, *Salix spp.*, were consumed. According to Doane, Van Dyke, Chamberlain and Burke (3) and Craighead (1), maples, *Acer spp.*, are also preferred species. Although sugar, red and striped maple were plentiful they were rarely taken in this area. The insects appeared to have little appetite for any of the conifers present on the area.

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Between July 8 and 10 nearly all the species that had been defoliated, except red oak, started leafing out. Recovery was estimated to be complete by July 23. These observations indicate a recovery period of 41 to 47 days. By ocular estimation, it was determined that in nearly all cases of moderate to complete defoliation the trees recovered only 60 to 75 percent of their original leaf surface area. The majority of the trees which were less than 25 percent defoliated failed to recover any of their lost leaf surface. Red oak failed to produce a second crop of leaves; however, in no area observed, was there a red oak which had been completely defoliated.

In order to show the effects of defoliation upon the diameter growth of aspen, four test trees and three check trees were selected. All the trees used in this study were from 5 to 7 inches in D.B.H.[1] and increment borings indicated that their diameter growth had been nearly equal for the 5-year period preceding this study. Three of the test trees were completely defoliated at the start of the study, and one test tree was approximately 25 percent defoliated. Growth measurements were first taken on June 22 and little, if any, additional defoliation occurred on the trees used in this study after that date.

Growth measurements were taken with a dial-gage dendrometer, employing the method described by Daubenmire (2). Observations were made at least twice a week starting June 22 and continuing through August 31. Weekly measurements were made until September 12. Growth data are shown in Fig. 1.

It is apparent from Fig. 1 that defoliation results in a marked decrease in diameter growth. At the end of the growing season (September 12) the defoliated trees showed only 33 percent as much growth as the check trees. The defoliated trees showed only a limited recovery in growth and there appeared to be a lag of approximately one month from time of recovery of leaf surface to any noticeable increase in the growth rate (August 25).

From the growth curve of the tree which was 25 percent defoliated, it would appear that the growth rate is roughly proportional to the amount of leaf surface removed. The 25 percent defoliated tree grew 62 percent as much as the check trees.

The results of this study would therefore indicate that widespread defoliation by the forest tent caterpillar results in a marked retardation of radial growth in aspen. In the case of completely defoliated stands, growth may be reduced by as much as 67 percent.

[1]Diameter at breast height.

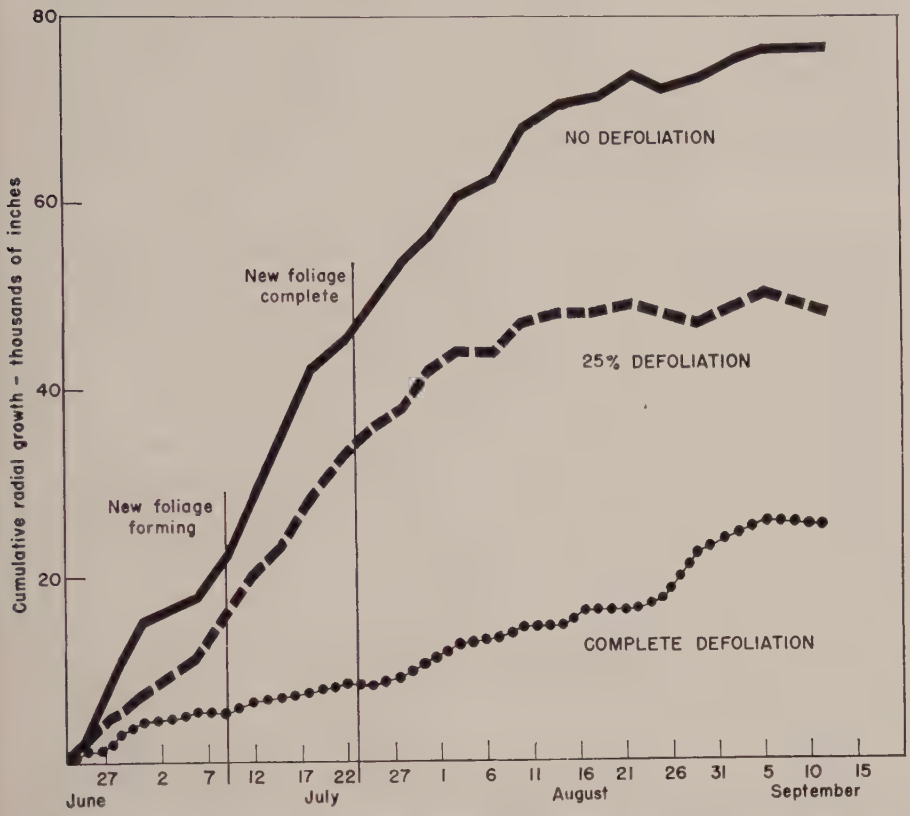

Fig. 1. Cumulative radial growth curves for aspen, June to September, 1950.

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DRYING LUMBER BY DESICCATING AGENTS

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ONE OF THE major problems confronting users of wood for interior purposes is how to dry it to a suitable moisture content. If the wood is too wet at the time it is fabricated subsequent drying will cause it to shrink and pull apart at the joints. If the wood is too dry it will take up moisture from the surrounding atmosphere and swell, causing warping, buckling, and sticking doors and drawers. At present the only practicable means of obtaining the desired moisture content is to dry the wood in a dry kiln or air-dry it outside until it reaches a moisture content of nearly 15 percent, then move it indoors to complete the drying. Large consumers can afford to build and operate dry kilns but the user of small quantities of lumber must either buy kiln-dried lumber, have his own lumber dried at a custom kiln, or resort to air drying. The purpose of the experiments described in this paper is to find a practical and economical method of drying lumber for the small user.

Desiccants have been used successfully in drying various farm products.[1] The method consists of impregnating porous materials such as wood or corncobs with solutions of calcium chloride or a similar hygroscopic salt and then drying them. These blocks of wood or corncobs are then placed in contact with the product to be dried and left until they become decidedly moist when they are replaced with a dry set. Of the materials used, it was found that small blocks of wood impregnated with calcium chloride were the most satisfactory and that the lighter, more porous woods took up moisture faster than denser woods.

PRELIMINARY TEST

In the first test of this method for drying lumber, three speeds of drying were used. Four boards, one pine, one basswood and two beech were used in each container. The containers were made of sheet metal

[1]Dexter, S. T. and J. W. Creighton, "A Method of Curing Farm Products by the Use of Drying Agents." Journal of the American Society of Agronomy, Vol. 40, No. 1, January 1948.

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and were 8 feet long and about 1 foot in diameter. For rapid drying, blocks totalling in weight 20 percent of the undried weight of the wood were placed in the container with the boards. For intermediate drying, 10 percent and for slow drying 5 percent of the weight of the undried wood were used. The use of larger numbers of blocks at one time necessitated less frequent changes of blocks.

Table 1 shows drying speeds of the three tests as indicated by the moisture contents of the lumber, determined weekly.

TABLE 1—*Moisture contents of boards, in percent*

	Elapsed time in weeks								
Rapid drying	Start	1	2	3	4	5	6	7	8 (end)
Pine	17.1	10.4	8.0	7.6	7.1	6.3	6.1	5.9	5.8
Basswood	17.1	9.7	7.5	7.1	6.1	5.6	5.4	5.4	5.3
Narrow beech	20.4	12.5	9.3	8.9	7.6	6.7	6.3	6.2	6.1
Wide beech	20.7	14.5	12.7	11.2	10.1	9.0	8.4	7.9	7.6
Intermediate drying									
Pine	17.3	12.0	9.8	8.6	8.3	7.8	7.6	7.0	7.0
Basswood	15.7	10.5	8.2	6.9	6.5	6.2	6.2	5.9	5.6
Narrow beech	19.1	13.1	10.0	8.8	8.1	7.7	7.3	6.8	6.5
Wide beech	18.7	13.5	10.8	9.6	9.0	8.4	8.1	7.6	7.2
Slowest drying									
Pine	17.5	14.3	12.2	11.1	10.0	8.8	8.1	7.9	7.3
Basswood	16.8	13.3	11.7	9.5	8.3	7.4	6.9	6.4	5.9
Narrow beech	19.0	14.9	11.8	10.4	9.3	8.0	7.2	7.1	7.7
Wide beech	21.4	18.2	15.4	14.2	12.9	11.7	10.8	8.6	8.3

Tests for casehardening taken after drying indicated that all three drying speeds were too rapid for beech and that rapid drying was too severe for pine and basswood. All the pieces were air dried before being subjected to the treatment, and possibly the stresses in the beech were set up before it was placed in the air-tight containers.

The above-mentioned tests indicated that lumber could be dried to a moisture content suitable for interior use by this method without damage to it, if drying were slow enough not to produce excessive stresses. The rapidly dried beech was severely casehardened and warped, and would be useless unless stresses could be relieved.

CONCRETE CHAMBER TEST

A second test of the method was run in a closed-off section of a ventilating tunnel, with walls, floor and ceiling of concrete, under the Michigan State College Horticulture Building. A chamber, 24 feet long, 10 feet wide and 6 feet high, was made at one end of the tunnel

by closing it off with vapor barrier paper. Ventilating ducts leading into it were plugged up. A total of 345 board feet of 4/4 and 425 feet of 8/4 rough yellow birch was stacked in separate piles, with courses of lumber separated by stickers one inch thick. The two piles were placed side by side, and the impregnated drying blocks were strung on wires and suspended along the sides of the piles. The blocks were removed and dried once during the run. The total weight of water picked up by the blocks was 1111 pounds. Records were kept on seven 4/4 and three 8/4 boards.

TABLE 2—Record for drying test in ventilation building

Sample	Original M.C.*	Lowest M.C. attained	Number of days in drying chamber to attain lowest M.C.
4/4 Thickness	percent	percent	
1	73.5	8.0	88
2	71.4	8.0	88
3	69.8	8.0	88
4	68.2	8.0	88
5	67.0	8.0	88
6	65.7	8.0	88
7	64.1	8.0	88
8/4 Thickness			
1	73.5	11.7	88
2	71.4	11.6	88
3	69.8	11.5	88

*M.C. — moisture content.

Table 2 shows the original moisture content, the lowest moisture content attained and the number of days in the chamber required for each piece to attain this moisture content. All the boards were left in the chamber a total of 88 days. The last column shows the number of days required by each sample to attain its lowest moisture content.

The mean relative humidity as measured in the chamber by a Foxx Hygrothermograph was 42.5 percent and by a sling psychrometer was 45.6 percent. The equilibrium moisture content ranged from 6.0 to 8.8 percent for lumber inside the chamber with a mean of 8.2 percent. Temperature ranged from 88° to 72° F. A control pile of 4/4 birch was left outside the chamber in the air vessel. Records of weight and relative humidity were not kept, but on the nineteenth and twenty-third days of drying the relative humidity was determined to be 13 and 14 percent, respectively, as contrasted to 38 and 45 percent inside the chamber. Equilibrium moisture content was 3.0 and 3.2 percent for lumber outside as contrasted to 8.0 and 8.6 percent inside the kiln. These conditions were reflected in the drying of the lumber.

in that the average moisture content of three boards was reduced from 16.3 to 7.1 percent by the fifteenth day of drying in the dry tunnel outside the chamber.

Comparison between the inside and outside of the chamber indicates that the effect of using the salt blocks in the chamber was to control rather than to reduce relative humidity in comparison with the dry tunnel air and, consequently, to retard drying. Even so, the salt blocks took up large amounts of water from the air, as previously shown. None of the boards inside or outside was casehardened so placing the boards in the chamber apparently accomplished nothing as far as the conditioning of the lumber was concerned.

Relative humidity tests were not taken near the bottom of the chamber, but the location of boards 5, 6 and 7 near the bottom of the pile indicates that because of lack of circulation the resulting temperature gradient caused the relative humidity to be higher near the floor.

At one period, between the 18th and 19th days, there were no blocks in the chamber for 24 hours. During this period the relative humidity dropped from 36 to 30 percent. Also, the relative humidity inside the chamber fluctuated with the outside weather conditions. On rainy days the relative humidity was high and on dry days, low. Results of this experiment indicate that the chamber itself was not moistureproof enough to give an adequate test of the method for drying lumber. It did show, however, that the blocks could be used to maintain relative humidity, and thereby control the rate of drying.

TEST IN CHAMBER IN DRY BASEMENT

Starting in January 1949, a test was run on 368 feet of 4/4 black cherry. A chamber 4 feet high, 4 feet wide and 14 feet long was built in the basement of a house heated by a coal furnace. The walls and floor were of asphalt-treated Celotex, lined with vapor barrier paper. The top was of sections of asphalt-treated Celotex, and the entire top was then covered with vapor barrier paper. The lumber, at 34 percent moisture content, was piled in the center of the chamber which was then closed for 5 days. During this period the samples lost only 1 percent in moisture content, indicating that the chamber was sufficiently air tight for the test.

It was found in previous experiments that the wooden blocks strung on a wire were bulky. In order to facilitate handling, 2″ x 10″ cottonwood planks were cut into 30-inch lengths and each of these lengths crosscut almost all the way through every half inch, leaving a narrow

strip along one side to hold the piece together. These blocks were then saturated with a 20-percent solution of calcium chloride, then dried by hanging near the furnace. Twenty such blocks were made and it was found by trial that each block gained in weight an average of 1.07 pounds in 24 hours during the initial stages of drying providing the blocks were given a 24-hour drying period beside the furnace after 24-hour exposures to the air in the chamber.

It was desired to dry the lumber from 34 percent to 10 percent in approximately 30 days. To do this it was first necessary to determine the total weight of water to be removed. The average specific gravity of black cherry is 0.58. To find the weight per cubic foot it must be multiplied by 62.4, the weight (in pounds) of one cubic foot of water. The weight of 368 board feet of cherry is then $\frac{368}{12} \times 0.58 \times 62.4 =$ 1107.5 pounds. The weight of 24 percent of water to be removed is $1107.5 \times 0.24 = 265.8$ pounds.

Removing 265.8 pounds in 30 days required an average daily loss of $\frac{265.8}{30}$ or 8.86 pounds. This amounts to approximately 0.8 percent daily. Eight blocks were in the chamber from the start until the twenty-second day and after that ten blocks were used. After 24 hours in the chamber wet blocks were exchanged for dry ones.

Column 6 on Table 3 shows that the actual loss of moisture content percentage was approximately the 0.8 percent desired through initial stages of the run and then declined. For that reason the number of blocks was increased to ten, starting the 23rd day, and the rate of drying again picked up. Also of interest is that the drying slowed down noticeably from the 12th to 14th days when the blocks were not changed.

The control shown in Table 3 was a pile of 96 board feet of 4/4 black cherry placed outside but beside the chamber. On the 4th day of drying the boards in the control pile showed noticeable end and surface checks. From the 15th to 17th days the surface checks closed up and did not become evident thereafter. The end checks also closed but remained evident. Checks on the control boards started closing when the moisture content reached 14 to 15 percent, indicating that the moisture content at the center of the board was below the fiber saturation point and that the center had started to shrink. This moisture content percentage was taken as an arbitrary figure as a moisture

TABLE 3—*Drying record for cherry*

Days	Sample 1		Sample 2		Average M.C. loss, samples 1 and 2	Control	
	M.C.*	Daily M.C. loss	M.C.	Daily M.C. loss		M.C.	Daily M.C. loss
1	2	3	4	5	6	7	8
	percent	percent	percent	percent	percent	percent	percent
Start	33.6	—	34.9	—	—	34.2	—
2	32.2	0.7	33.3	0.8	0.75	31.1	1.55
4	30.7	0.75	31.9	0.7	0.725	28.5	1.3
6	29.0	0.65	30.1	0.9	0.775	25.7	1.4
8	27.2	0.9	28.4	0.85	0.875	24.0	0.85
10	25.9	0.65	26.9	0.75	0.7	21.3	1.35
12	24.4	0.75	25.4	0.75	0.75	18.9	1.2
14	23.6	0.4	24.7	0.35	0.38	16.4	1.25
16	21.8	0.9	22.8	0.95	0.93	14.0	1.2
18	20.4	0.7	21.5	0.65	0.68	12.2	.9
20	19.1	0.65	20.2	0.65	0.65	10.6	0.9
21	18.5	0.6	19.5	0.7	0.65	9.8	0.8
22	18.0	0.5	18.9	0.6	0.55	9.2	0.6
23	17.3	0.7	18.2	0.7	0.7	8.7	0.5
24	16.4	0.9	17.4	0.8	0.85	8.2	0.5
26	15.1	0.65	15.9	0.75	0.7	7.1	0.55
27	14.5	0.6	14.9	1.0	0.8	6.8	0.30
28	13.0	1.5	13.6	1.3	1.4	6.5	0.3
29	11.5	1.5	12.0	1.6	1.55	6.4	0.1
30	10.2	1.3	10.8	1.2	1.25	6.4	—
31	9.5	0.7	10.1	0.7	0.7	6.3	0.1
32	—	—	9.6	0.5	0.5	6.5	0.2

Notes: On 12th day blocks were not changed.
On 22nd day and after 10 blocks were used instead of 8.
On 27th day blocks were removed and kiln opened.
*M.C.—moisture content.

content at which it would be safe to expose the lumber in the chamber to the dryer air outside. However, this is not to be considered as a reliable way to determine when danger of checking has passed, for this can only be determined by making stress or moisture gradient tests. When the lumber reached this point the chamber was opened. The use of the salt blocks was then discontinued. The boards which were dried inside the chamber showed no seasoning defect at any time during the run. Casehardening tests taken 14 days after the end of the run showed no interior stresses present. The wood was then used for interior cabinet work. The boards in the control pile, however, were decidedly warped and cupped, and slightly casehardened. Pressure of the planer rolls split some of the boards and planing exposed surface checks. The wood from the control pile was unfit for the cabinet work for which the chamber dried lumber was used.

In conducting this test, equipment and methods were used which could be duplicated at small cost. Blocks were dried by hanging them beside a furnace. Moisture content used was that determined from an accurate balance and with samples dried in an electric oven at 100°

C. Moisture content was also determined by using an ordinary egg scale for weighing the thin cross-sectional pieces and by drying these pieces in hot air pipes in the house heating system, and on top of the furnace. Moisture content of sample 1, while actually 33.6 percent, was determined in four trials by these methods to be 30, 31, 30 and 32 percent. This is not accurate enough for experimental work but will suffice unless exact moisture contents are required. Postal scales can also be used for weighing, but any scale reading in decimals will be found to be much easier to work with than one reading in ounces.

As may be seen by comparing columns 6 and 8 in Table 3, the actual action of the chamber and blocks in this test were to retard the rate of drying as compared with drying in the dry air of the basement. This could probably have been done in the same chamber by providing vents for air to circulate between the outside and inside of the chamber. The fact that lumber was piled inside for a period of 5 days without blocks, during which it did not dry, indicates that the drying blocks would have worked approximately as effectively, even if the relative humidity outside the chamber were too high for drying to occur outside.

Advantages of this method over air drying outside with a subsequent move inside are:

1. The method gives some control of relative humidity and consequently the rate of drying, thus making possible the drying of the wood without subjecting it to excessive stresses.

2. Lumber can be piled indoors when green thus eliminating the move from outside to inside for final stages of drying.

The chief disadvantage of the system was found to be in the handling of the blocks. While they were considerably easier to handle than the small ones hung on wires, they still required daily changing, and for a large amount of lumber a great number of blocks would be needed. If a more efficient system of drying the blocks were provided, the blocks could be dried further and would, therefore, require less frequent changing.

In order to use an adaptation of the method to control the rate of the initial stages of drying, a box 12 by 18 by 40 inches was made. The bottom, top and three walls were lined with vapor-barrier paper and all joints covered with black dry-kiln mastic. The fourth wall was made as a door hinged on top, consisting of an open frame across which was stretched two thicknesses of heavy burlap which had been soaked in a 20-percent solution of calcium chloride, then dried. The purpose

of the curtain was to provide a more or less automatically drying desiccant which would eliminate the need for handling blocks. It was thought that the moisture would pass from the lumber within the box to the air surrounding it, to be absorbed by the curtain. The drier air outside would then evaporate the moisture from the curtain.

Five pieces of red oak 1 by 6 by 14 inches were placed in the box and separated by 1 by 1 stickers. Relative humidity and temperature were recorded inside and outside the box on hygrothermographs which were checked against each other, and by a sling psychrometer. Record sheets were changed weekly. Both the box and the control instrument were placed outdoors but in the shade. Neither was touched by direct sunlight. The drying record is shown in Table 4.

TABLE 4—*Record for 4/4 flat-sawn red oak dried in box with calcium chloride curtain*

Date	Days	Moisture content	
		Sample	Control
		percent	percent
6–22–49	Start	38.4	39.2
23	1	36.4	36.5
25	3	33.8	33.4
27	5	32.4	32.1
30	8	30.7	29.3
7– 5–49	13	27.2	25.9
7	15	26.3	24.6
9	17	25.4	23.6
11	19	24.8	22.5
19	27	22.7	20.5
25	33	20.8	18.7
8– 1–49	40	18.9	16.9
8	47	18.3	16.5
9– 6–49	76	16.1	16.7
10–17–49	117	15.2	16.5
11– 1	132	15.0	16.5
11–17	148	15.3	16.7
12– 1	161	16.3	16.8

Note: Door left open on 11-15 and after.

From Table 4 it may be seen that the rate of drying in the curtained box was only slightly slower than for the wood dried in the open right beside it. It did dry to a slightly lower moisture content but the difference was negligible. Possibly the more rapid drying of the control outside the box was caused by better air circulation.

The range of recorded relative humidity and temperature and the calculated equilibrium moisture content over the entire run are shown in Table 5.

TABLE 5—*Range of relative humidity, temperature and equilibrium moisture content inside and outside curtained box*

	In box	Outside box
Relative humidity	56—80 percent	26—100 percent
Equilibrium moisture content	10.3—16.1 percent	5.2—21.5 percent
Temperature	5°—93°F.	5°—93°F.

Insofar as the drying of lumber is concerned, only the temperature and equilibrium moisture content are significant, and the temperature was the same inside and outside the box.

Table 5 shows that the effect of the box was to reduce the range of the equilibrium moisture content. Actually the fluctuation was not so great as is indicated in Table 5 because the extremes in the range were reached only on a rapid change of temperature and tended to drop back quickly toward the mean. More significant is a comparison of equilibrium moisture content between the inside and outside of the box taken at 6-hour intervals over a period of 216 hours. This comparison showed a mean of 13.58 percent inside and 14.15 percent outside the box. The standard deviation was 1.13 percent inside and 3.77 percent outside. On the basis of this sample then, the equilibrium moisture content might be expected to be between 12.3 and 14.7 percent during 68 percent of the time and between 11.2 and 15.8 percent for 95 percent of the time inside the box. In contrast it would be between 10.4 and 17.9 percent for 68 percent of the time and between 6.6 and 21.7 percent for 95 percent of the time outside the box.

It cannot be assumed that the equilibrium moisture content will be held at this range by the calcium chloride curtain under all conditions, for the range would doubtless be affected by nature of the material inside the box, the size of the curtain in proportion to the size of the box, the concentration of calcium chloride in the curtain, the temperature, and the exterior relative humidity.

The maintenance of the equilibrium moisture content within the chambers apparently reduced the stresses in the lumber. At no time did surface checking develop on the interior wood, while on that dried outside checks developed after the 4th day of drying and remained apparent throughout the run. Neither sample showed casehardening at the end.

A second calcium chloride curtain test was run on 500 board feet of oak and cherry, in a box 3 feet 6 inches wides, 4 feet 6 inches high and 10 feet long, lined with moisture-barrier paper. The curtain

covered only one end of the chamber and was exposed so that rain falling on it leached out the calcium chloride. It was practically all leached out by the end of the third week. Red oak samples placed in the chamber on August 8, 1949, with a moisture content of 60-62 percent had dried to 35-45 percent by December 13, 1949. Control samples with the same original moisture content dried to 20-21 percent outside the chamber. Recordings showed a continuously high relative humidity inside the chamber. Wood very near the calcium chloride curtain dried to 25 percent while that in the rear was as high as 47 percent when removed, indicating that circulation of the air was not adequate.

This test indicated only that a much larger curtain area is required than that provided, and that provisions must be made to prevent leaching of the salt.

SUMMARY

Blocks of wood impregnated with hygroscopic salts can be used effectively in drying lumber, providing an air-tight chamber is provided in which to pile the lumber. The effect of the blocks is to control rate of drying rather than to speed up drying and by this control to reduce internal stresses in the wood. Seasoning defects can thereby be prevented. The method can be used by consumers of small quantities of lumber to dry it to desired moisture contents at a very low cost.

The use of a curtain impregnated with a hygroscopic salt between the air in the chamber and the outside air offers some possibility of eliminating the need for exchanging blocks in using this method for drying lumber.

THE VOLUME OCCUPIED BY FUNGUS HYPHAE IN RASPBERRY FRUITS[1]

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DURING THE PAST YEAR there has been considerable interest concerning the significance of mold counts in black raspberries that range between zero and one-hundred percent of the microscopic fields in the Howard mold-counting chamber. The Howard mold count method (1) has been developed as an aid in determining the amount of mold in tomato products. Needham and Fellers (2) have shown that the microscopic count of molds by the Howard method can be applied to berries and berry products to determine the character of the product, especially in blackberries. This method is also being used to detect mold in black raspberries. However, the structure of the wall and the fruit of the black raspberry is much weaker in comparison to that of the blackberry. The delicate black raspberries are much more susceptible to development of fungi in the ripening of fruits during hot, humid weather which results in higher mold counts in the microscopic fields as determined by the Howard method. Even though the counts might be considered high by this method the actual volume occupied is extremely small for the two fungi, most frequently found in ripe raspberry fruits, *Alternaria humicola* Oudemans and *Cladosporium epiphyllum* Persoon. This is shown by the following volume calculations that were made for fungi found in the black raspberry puree.

A puree sample of canned black raspberries was examined microscopically, and measurements were made of 20 hyphal fragments therein, in order to determine the actual volume of fungus in fruit for which Howard mold counts are stated as percent of positive fields. The sample examined had a 56 percent mold count as determined by the Howard mold count method.

Some of the mycelium measured was identified as *Alternaria sp.* as evidenced by the presence of typical *Alternaria* spores. The following is a list of the ranges in microns for diameters of the hyphae present

[1]This is contribution 50-2, Department of Botany and Plant Pathology, Michigan State College.

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in the fields examined in the puree: 3.9, 2.6, 2.6, 2.6, 2.6, 3.9, 4.5, 3.9, 5.2, 3.9, 3.9, 6.0, 5.2, 3.9, 5.2, 3.9, 3.9, 2.6, 5.2, 6.0.

After the diameters of the hyphae were determined, the volume of a single hypha was calculated. The length of the hypha was considered as 1/6 of the diameter of the field as this is the minimum length required for a positive field. Since 1/6 of the diameter of the microscopic field equals almost 0.23mm. or 230μ, the figure of 230μ was used in calculating the volume. As most fungus threads are nearly cylindrical, the formula for a cylinder, $\pi r^2 1$, was used. By substituting the minimum length (230μ) and the minimum (2.6μ) and the maximum (6μ) widths of the hyphae in the formula the following volumes were determined after conversion of microns to millimeters:

SIZE OF HYPHAE	VOLUME OF HYPHAE
230μ long by 6μ in diameter	0.000006499 cu. mm.
230μ long by 2.6μ in diameter	0.00000122 cu. mm.

The foregoing figures for the volume of hyphae represent the smallest and largest ones that were found in the black raspberry puree.

The Howard mold counting chamber is 0.1 mm. in depth and the area of the field in the microscope is 1.5 sq. mm. which makes the volume of one field 0.15 cu. mm. In making mold counts on black raspberry puree, it is necessary to dilute the puree with an equal volume of pectin solution to facilitate counting. Therefore, it is necessary to multiply the mold count in each field by two. With one hypha in a field, the volume of the fungi may be determined by multiplying the number of fields with fungi by the volume occupied by a single hypha. In a 2-percent count, the volume of two large hyphae would be 0.000012998 cu. mm. Since 100 fields would contain 15 cu. mm. of liquid, the percentage of the volume can be determined by dividing 0.000012998 cu. mm. by 15 cu. mm., which is 0.00000086 or 0.000086 percent. As 15 cu. mm. represents a 50-percent puree, it is necessary to multiply the final result by 2. This would give 0.00000173 of the volume of 0.000173 percent of the volume of a 2-percent Howard mold count. In a similar way the volume for higher counts up to 100 percent may be determined. These are shown in the following tables.

The figures for the volume occupied by fungi represent typical forms that are most commonly found in black raspberries. The range of 0.00162 to 0.0087 percent for 100-percent counts is the minimum volume of the mold that could be counted to get this percentage. There are occasions when there may be more than one hypha in one field. In accordance with the standard counting procedure, this would still

TABLE 1—*If the maximum width of the fungus equals 6μ in diameter or has a volume of 0.000006499 cu. mm. for each hypha, then the following volumes are the minimum amounts of fungi present in the mold counts:*

Mold count percent of fields	Volume of fungi	Volume of 100 fields, 50% puree	Percent of volume, if 100% puree
2	.000012998 cu. mm.	15 cu. mm.	.00000173 or .000173%
20	.00012998 cu. mm.	15 cu. mm.	.0000173 or .00173%
40	.00025996 cu. mm.	15 cu. mm.	.0000346 or .00346%
80	.00051992 cu. mm.	15 cu. mm.	.0000692 or .00692%
100	.0006499 cu. mm.	15 cu. mm.	.000087 or .0087%

TABLE 2—*If the minimum width of the fungus equals 2.6μ in diameter or has a volume of 0.00000122 cu. mm. for each hypha, then the following volumes are the minimum amount of fungi present in the mold counts:*

Mold count percent of fields	Volume of fungi	Volume of 100 fields, 50% puree	Percent of volume if 100% puree
2	.00000244 cu. mm.	15 cu. mm.	.00000032 or .000032%
20	.0000244 cu. mm.	15 cu. mm.	.0000032 or .00032%
40	.0000488 cu. mm.	15 cu. mm.	.0000064 or .00064%
80	.0000976 cu. mm.	15 cu. mm.	.0000130 or .00130%
100	.000122 cu. mm.	15 cu. mm.	.0000162 or .00162%

be counted the same as a single hypha. Also, fragments too small to be counted would not be included in the percentage reported. However, even if we were to double or triple the volume of fungi in black raspberries to cover such occasional situations, when more than one hypha may be seen in a field, the total amount would still be infinitesimal even in counts up to 100 percent.

The volume of mold in the black raspberries as shown in the tables is extremely small even when the number or percentage of positive microscopic fields is high as determined by the Howard mold counting method. The fungi usually causing the high mold counts for black raspberries during the summer of 1950 have been determined as *Alternaria humicola* and *Cladosporium epiphyllum*.

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EFFECTIVENESS OF DEHYDROACETIC ACID AS A MOLD INHIBITOR ON BUTTER AND CHEESE SURFACES

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THE MANUFACTURE of cheese and butter completely free of contaminating mold presents a most difficult problem in production control. It must be assumed, however, that the application of efficient, intelligent sanitary procedures in the handling of milk and cream will effectively eliminate gross contamination by mold mycelia and spores. Stiritz (1922), Wildman (1940), and others have shown that the equipment used in manufacturing butter, especially the churn, is often a major factor contributing to the contamination of butter. In most instances this source of contamination could be eliminated by careful cleaning and sterilization procedures for all equipment. In general, the accepted practices of "good housekeeping" will do much to lower the incidence of contamination by processing equipment and procedures.

Unfortunately, the probability is that complete elimination of mold contamination cannot be totally achieved in the dairy plant. Much depends upon the methods used in the production of milk and cream on the farm. According to Macy and Combs (1927) poor handling methods at the source of production usually account for the high incidence of heavily contaminated raw cream, both sweet and sour, delivered to midwestern creameries. These workers were also cognizant that ordinary pasteurization of heavily contaminated creams did not entirely inhibit mold growth in butter. Although Adams and Parfitt (1939) pointed out that the presence of mold-mycelia fragments in butter serve as an index of the quality of cream used in its manufacture, an opinion generally shared by most dairy sanitarians,

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their presence, according to Macy and Ritchi (1929), does not indicate necessarily the keeping quality of the finished butter. Vernon (1947) emphasized the importance of the specific activity of the contaminating mold rather than the quantitative "mold mycelia index" in relation to the keeping quality of butter. This concept concurs with the observations of Combs and Eckles (1917-18) who, many years before, believed that tainted flavors encountered in moldy butter were a result of specific enzymes secreted by molds.

Because of the difficulty in trying to eliminate completely all sources of mold contamination from production and manufacturing sources, and because mold contamination in butter and cheese is most generally manifested in unsightly, troublesome surface growth, many investigators have attempted to suppress mold growth. An attempt to reduce mold growth on butter by carbonation was reported by Prucha *et al.* (1925). Direct carbonation of the cream, and churnings made under an atmosphere of carbon dioxide were ineffective as mold inhibiting measures. Only when butter was stored in an airtight, carbon dioxide atmosphere at cold storage temperatures was carbonation of any value. Macy (1930) reported a general decrease in total mold growth on salted butter as compared with an increase in mold growth on unsalted butter held at the same storage temperature. In subsequent studies, Macy and Steele (1934) recommended storage temperatures below 5° C. for unsalted butter if surface mold was to be controlled effectively. Some interest has been expressed in the application of ultraviolet radiations as a means of reducing the incidence of airborne mold contamination in the handling of butter and cheese. However, Smith (1942) was unable to suppress or reduce mold growth on mold inoculated cheese samples exposed to UVL radiations ranging from 2500 to 2600 Angstrom units. A successful mold-suppressing technique was reported by Palmer and Combs (1919) who observed that surface mold on butter samples could be prevented by placing the butter in airtight containers under an atmosphere of ethyl alcohol. By the application of a somewhat similar principle, Mallmann (1941) was able successfully to retard mold growth on cold storage food materials subjected to a partial atmosphere of carbon dioxide or ozone.

A more direct approach to the control of surface mold on butter and cheese has been made in studies involving the use of certain fungicidal or mycostatic chemicals. Since it is questionable whether mold stabilizers should be added directly to butter or cheese, and because

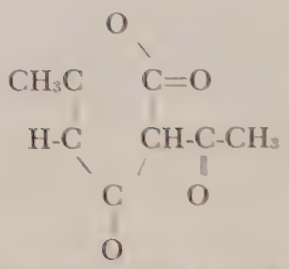
mold contamination is usually manifested in surface growth, most of these studies were undertaken with the idea of bringing only the surface of butter and cheese in contact with the chemicals, thus reducing to a minimum the amount of antimicrobial agent actually picked up by the treated materials. This was generally accomplished by either one of two techniques: *a)* impregnation of the wrapping material or by *b)* dipping the butter or cheese in a dilute solution of the mold inhibitor. Among the first mold-inhibiting materials investigated were the fatty acids. Hoffman *et al.* (1939). Among these, propionic acid and its calcium and sodium salts have shown the most promise, and their use, both as a dip for butter and cheese and as an impregnant for wrapping materials, has been reported by Irvine and Sproule (1940), Miller (1940), Johns (1940) Ingle (1940) and others. In general, the solutions of calcium propionate were more effective fungistats than were the solutions of the sodium salt. As reported by Olsen and Macy (1945), 5-percent calcium propionate solution, adjusted to a pH 5.5, was as effective as a 10-percent solution at pH 8.3, an observation which they later (1946) attributed to the undissociated propionic acid molecule. Additional studies directly related to the use of contact mycostats were reported by Mallmann and Michael (1940), who concluded from their experiments with mold growth on egg flats held in cold storage lockers that the impregnation of the flats with sodium pentachlorophenate was an effective means of eliminating surface-mold on storage eggs. More recently, Pearl and McCoy (1945) reported that certain esters of vanillic acid have shown mold-inhibiting activity when added to foodstuffs. Finally, the announcement by Wolf (1950) that dehydroacetic acid and its sodium salt possess relatively high antimicrobial activity has initiated the investigations reported in this paper.

MATERIALS

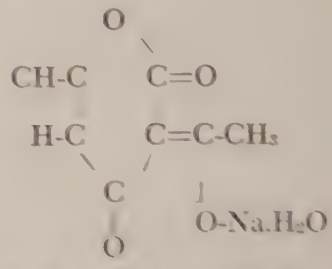
The purpose of this study was to determine the effectiveness of dehydroacetic acid and its sodium salt as mycostatic or fungicidal agents in suppressing surface-mold growth on butter and cheese during storage.

ANTI-MICROBIAL AGENT

Dehydroacetic acid (3-acetyl-6-methyl—1,2-pyran 2,4 (3)—dione) and its sodium salt which are represented by the following structural formulae were used:



Dehydroacetic acid DHA[2]



Sodium salt of dehydroacetic Acid DHA[2]

These materials are white powders and are colorless, odorless, and tasteless in use solutions. The acid form (DHA) is soluble in organic solvents, moderately soluble in oils and waxes, very slightly soluble in water. The sodium salt (DHA-S) is very soluble in water and only slightly soluble in organic solvents. According to Wolf (1950), dilute solutions of DHA-S were not materially destabilized after heating at 120°-130°C. for approximately one hour.

TEST ORGANISMS

Ten mold spots, picked from the surfaces of butter and cheese, were cultured on Czapek's mold-agar slants. Three apparently pure cultures were selected as test organisms and identified as (I) *Penicillium expansum*, (II) *Penicillium roqueforti*, and (III) *Rhizopus nigricans*. Transfers were made every seven days to working cultures from which standard mold-spore suspensions were prepared to be used as inoculum for the experimental substrate studied.

EXPERIMENTAL RESULTS

CONCENTRATION OF DHA-S REQUIRED TO INHIBIT GROWTH OF TEST ORGANISMS ON CZAPEK'S MOLD-AGAR

It was anticipated that the water-soluble DHA-S would be more applicable to the treatment of butter and cheese surfaces than would the water-insoluble DHA, since it could be used either as a dip or as an impregnant for parchment wrapping paper. Two hundred ml. quantities of Czapek's mold-agar were sterilized in an autoclave at a pressure of 15 p.s.i. for 20 minutes. Before the medium had cooled to the pouring temperature, DHA-S was added to five of the flasks, making concentrations of 0.01, 0.02, 0.03, 0.05, and 0.10 percent. The sixth flask was used as a control. The medium was poured in previous-

[2]Dow Chemical Company Trademarks for dehydroacetic acid (DHA) and its sodium salt (DHA-S)

ly prepared, sterile Petri plates to which 2 ml. of standard mold-spore suspension had been added. These plates were held for 7 days at 24° C., preliminary to making observations for mold growth. Fig. 1 shows the growth attained by each of the test molds after 7 days' incubation. Both species of *Penicillia* were able to grow at DHA-S concentrations of 0.02 percent but not at 0.03 percent. *R. nigricans* was able to grow on all concentrations of DHA-S up to and including 0.03 percent, being inhibited somewhere between 0.03 and 0.05 percent. This growth cannot be ascertained in Fig. 1 because the sporangia of *R. nigricans* are black and, consequently, did not photograph well against the black background.

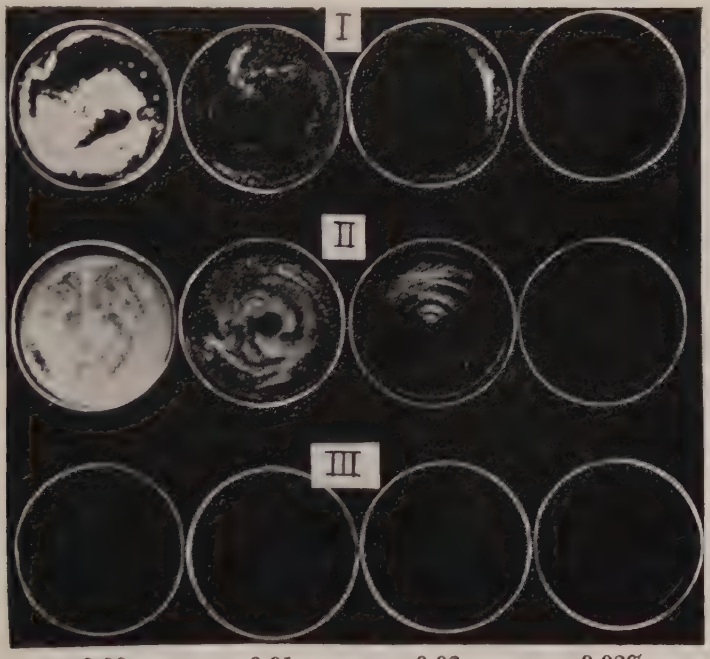


Fig. 1. Growth of test organisms on Czapek's mold agar containing various levels of DHA-S.

I. Penicillium expansum
II. Penicillium roqueforti
III. Rhizopus nigricans

After 21 days' cultivation, all of the test organisms were growing on higher concentrations of DHA-S than was previously noted. This time/growth relationship is shown in Table 1. An observation of this nature leads to the hypothesis that the added antimicrobial agent

TABLE 1—*Relationship between the concentration of DHA-S in Czapek's mold agar and time of cultivation on the growth of three test organisms*

Concentration of DHA-S in Czapek's media	Relative growth of test organisms at time of observation								
	Penicillium expansion			Pencillium roqueforti			Rhizopus nigricans		
	7 days	14 days	21 days	7 days	14 days	21 days	7 days	14 days	21 days
Percent									
0.00	+++	++++	++++	+++	++++	++++	++++	++++	++++
0.01	++	+++	+++	++	+++	+++	+++	++++	++++
0.02	+	++	+++	+	++	+++	++	++++	++++
0.03	−	+	++	−	+	++	+	++	+++
0.05	−	−	+	−	−	+	−	+	+++
0.10	−	−	−	−	−	−	−	−	+

(DHA-S) was functioning as a mycostat rather than as a mycocide. To test this hypothesis, a small disk of medium, taken from a completely inhibited plate of *R. nigricans* containing 0.05 percent DHA-S, was transferred to a sterile Petri plate and poured with Czapek's agar. In 14 days a luxurious growth was observed (Fig. 2).

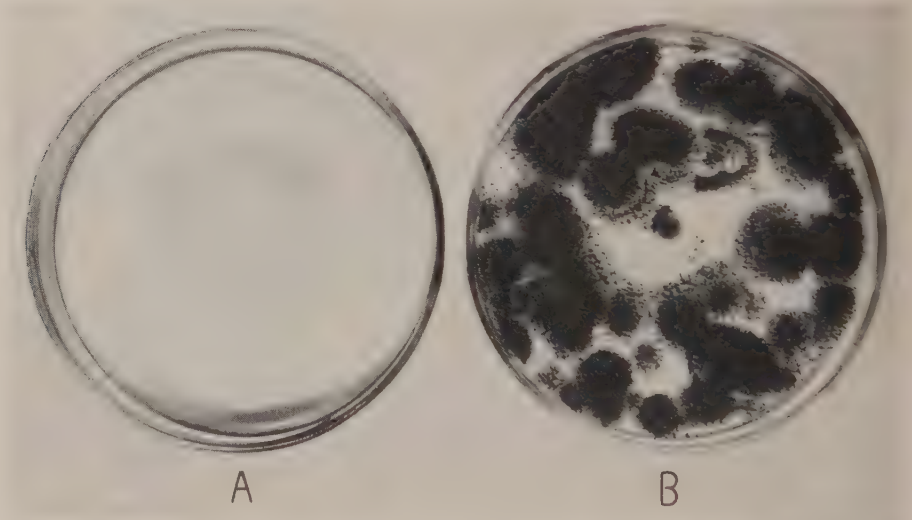


Fig. 2. Effect of dilution on a DHA-S inhibited inoculum of *Rhizopus nigricans*. A—*R. nigricans* spore-suspension plus 0.05 percent DHA-S in Czapek's mold agar. B—Czapek's mold agar plus a small amount of inoculum from plate A.

EFFECTIVENESS OF DHA-S AS A MYCOSTATIC RINSE AND SPRAY

The mycostatic activity of DHA-S in a mold-supporting medium having been demonstrated, the next experimental approach was to demonstrate the effectiveness of a DHA-S water solution as a mycostatic rinse or spray on mold-supporting surfaces. Three series of

three plates were poured with Czapek's mold agar; allowed to harden and the surface seeded with 5 ml. of a standard mixed mold-spore suspension obtained from cultures of each of the three test organisms. Plate A was held as a control, while plates B and C were rinsed with 20 ml. of sterile water and 1 percent DHA-S/water solution, respectively. These plates were examined after 7 days' cultivation at about 24° C. and are typified by the photographs in Fig. 3. Assuming that the mechanical agitation of rinsing was comparable in the two rinsing procedures, the significant inhibition of mold growth on plate C must be accounted for on the basis of the mycostatic properties of the residual DHA-S. Similar results were obtained with three blocks of wood treated in the same manner and held for 14 days at about 24° C. in an atmosphere of high relative humidity.

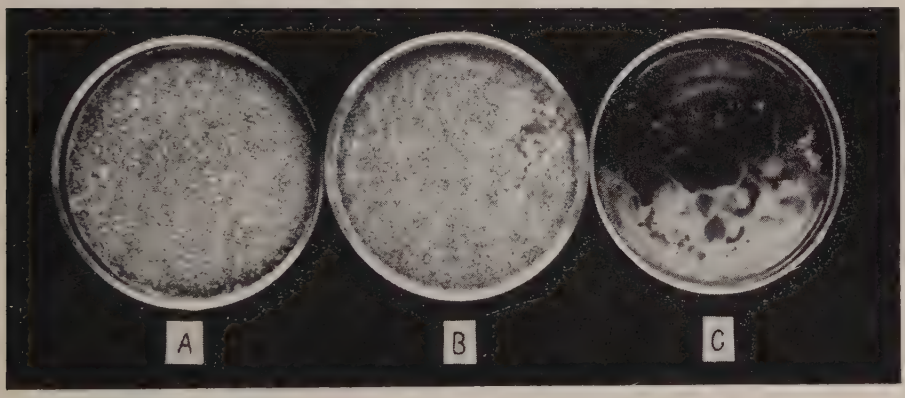


Fig. 3. The effectiveness of rinsing as a means of eliminating contamination from the surface of Czapek's mold agar. A—Control. B—Rinsed with 20 ml. of sterile water. C—Rinsed with 20 ml. of 1.0 percent DHA-S/water solution.

Because it is not always practicable to rinse contaminated surfaces, the feasibility of using a 1-percent DHA-S/water spray was investigated. Two series of Czapek's agar plates were poured. To series *IA* mixed mold-spore suspension was added to the liquid medium prior to its solidification. In series *II* the mold-spore suspension was rinsed over the surface of the hardened agar plate. The results of these trials after 14 days' cultivation at about 24° C. are shown in Fig. 4. Plates *IA* and *IIA* represent controls. Plates *IB* and *IIB* were sprayed once, one hour after seeding, with approximately one ml. of a one percent DHA-S/water solution. Apparently the residual concentration of DHA-S on the surface of plate *IB* was not sufficient to inhibit the development of the mixed mold-spore suspension in-

corporated within the medium. In other trial plates *IC* and *IIC* where the seeded plates were sprayed every 24 hours, the concentration of DHA-S was sufficient to retard further mold growth.

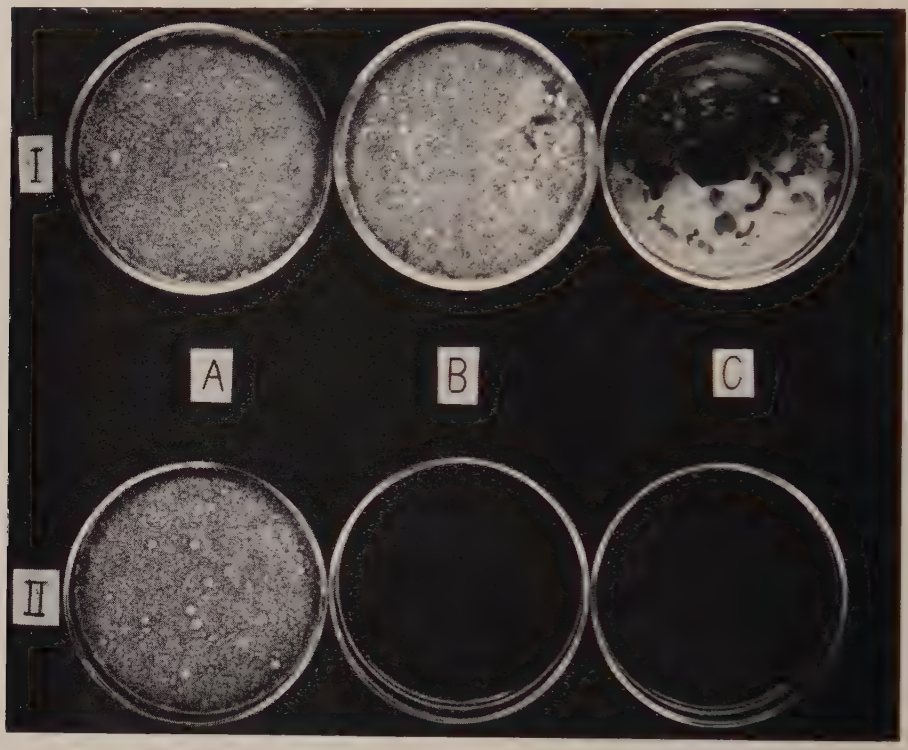


Fig. 4. The effectiveness of a 1.0 percent DHA-S water spray as a means of reducing mold growth on Czapek's agar inoculated with a mixed mold-suspension. A—Control. B—Sprayed once. C—Sprayed once every 24 hr. In Series I the inoculum was added to medium. In Series II the inoculum was poured over the surface of the hardened medium.

Figure 5 depicts the mycostatic effectiveness of a one percent DHA-S/water spray applied every 24 hours to a contaminated wood surface. Two small blocks of Douglas fir were seeded by total immersion in a water suspension of mold-spores. Following this treatment the blocks were suspended within a sterilized glass jar to which 25 ml. of sterile water had been added. Block *A* (control) was untreated during the test period. Block *B* (treated) was sprayed every 24 hours with a 1-percent mycostatic spray.

The apparently effective mycostatic action of dilute solutions of DHA-S on clean surfaces leads one to question whether this treatment would be equally effective on an established growth of the test organisms. Twenty-one-day plate cultures of the three test organisms on Czapek's medium were sprayed with a 1-percent DHA-S/water solution every 24 hours for 14 days. The results, as shown in Fig. 6, conform to what the authors might have anticipated from the results of their previous experiments. The mycostatic agent was effective only in retarding new growth without measurably affecting the established flora.

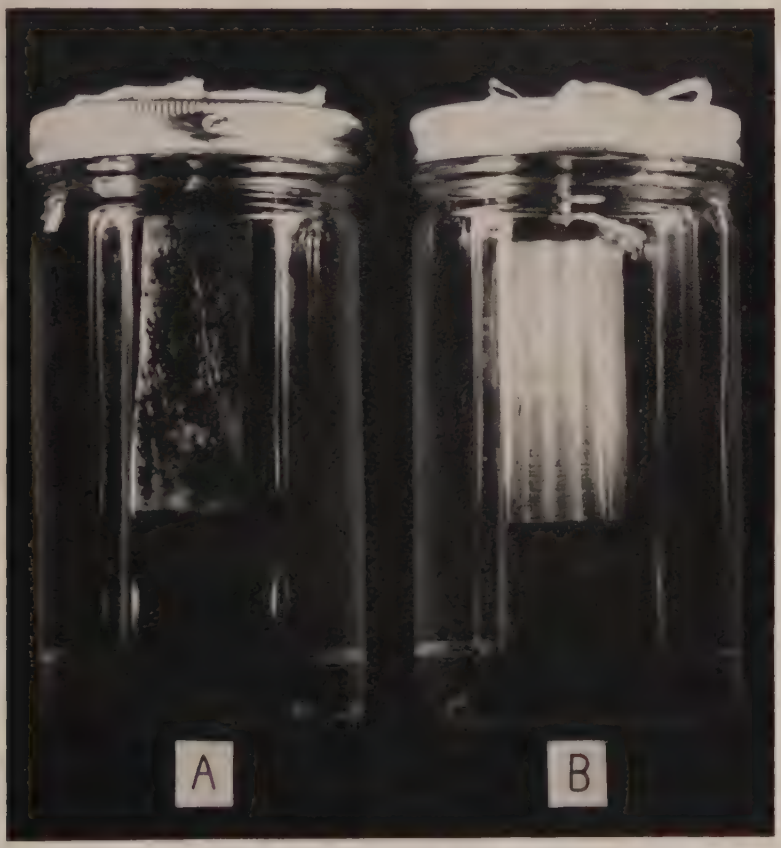


Fig. 5. The mycostatic effectiveness of a 1.0 percent DHA-S water spray applied to contaminated wood surfaces. A—Control. B—Sprayed once every 24 hours.

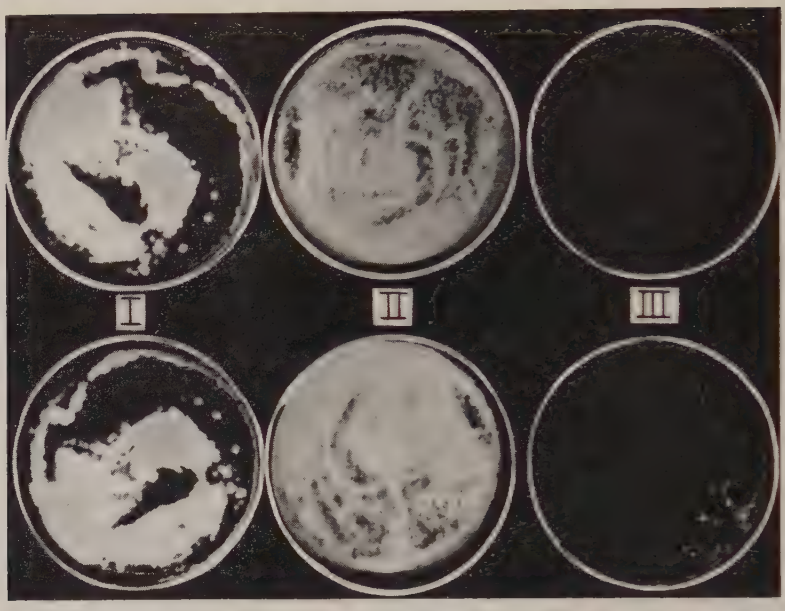


Fig. 6. Showing the effect of daily applications of a 1.0 percent DHA-S/water spray to established cultures of the test organisms. A—21 day cultures of the test organisms. B—Same cultures after 14 daily treatments.

I. Penicillium expansum
II. Penicillium roqueforti
III. Rhizopus nigricans

MYCOSTATIC EFFECTIVENESS OF DHA AND DHA-S WHEN APPLIED TO THE SURFACES OF BUTTER AND CHEESE

As already demonstrated in these experiments, DHA-S has functioned effectively as a mycostatic agent only as long as the concentration of DHA-S in contact with the contaminated surfaces was great enough to inhibit the development of the mold spores. We will assume, as does Macy (1930) that the majority of mold contamination in butter and cheese is manifested on the surface, next to the wrapping material. Therefor, by immersing butter or cheese in a dilute DHA-S/water solution or by impregnating parchment or paraffin wrapper with the mycostatic agent we should be able to retard the unsightly and damaging surface-growth of mold contamination, thus effecting an improvement in the quality of these dairy products upon storage.

The experimental design described here is typical of several trials conducted in this phase of the study. Six quarter-pound slices of

a "91 score" sour cream butter and a "93 score" cheddar cheese were totally immersed in a mixed mold-spore suspension and treated as outlined in Table 2. Figure 7 shows the results obtained with cheese samples stored 14 days under conditions of high relative humidity at about 0° C. Cheese samples *IA* and *IIA* were wrapped in dry parchment and stored as controls. Sample *IB* was wrapped in dry, DHA-S impregnated parchment. Sample *IC* is representative of a contaminated sample wrapped in wet, DHA-S treated parchment. It should be noted that the wet-wrap technique most effectively retarded mold growth, totally eliminating growth at all contact surfaces. Series *II* shows the relative mycostatic effectiveness of the wet-wrapping technique versus the mycostatic-dip technique as a means of retarding surface contamination. Sample *IIB* was wrapped in wet, DHA-S impregnated parchment, whereas Sample *IIC* was dipped in a 1-percent DHA-S/water solution prior to wrapping in wet, impregnated parchment. It is obvious that the total immersion technique is superior to the wet-wrap method.

Coating cheese surfaces with paraffin has long been recognized as an accepted method of retarding mold growth on cheese surfaces. Nevertheless, the addition of 0.5 percent of DHA to the paraffin dip serves to lengthen the mold-free storage life of contaminated cheese. This was true especially when the paraffin layer was ruptured in some manner. The relative effectiveness of the various wrapping and dipping techniques, used in this study as a means of inhibiting surface-mold growth, is reported in Table 2.

DISCUSSION

Whether there is a justifiable, legitimate place for the use of a satisfactory mold stabilizer in the packaging of dairy products will not be argued here. This study was conducted purely to evaluate the mycostatic properties of dehydroacetic acid and its sodium salt as applied to the storage of butter and cheese. It was felt that fundamental studies of this nature might add materially to the information available relative to the packaging of these products to be transported and stored under adverse conditions, much as were encountered by our armed services during World War II. Extensive toxicological studies conducted by Spencer *et al.* (1950) with laboratory animals and to a limited extent with human subjects indicated that DHA and DHA-S were toxic only when administered in amounts far in excess of that which could possibly be acquired under normal use concentra-

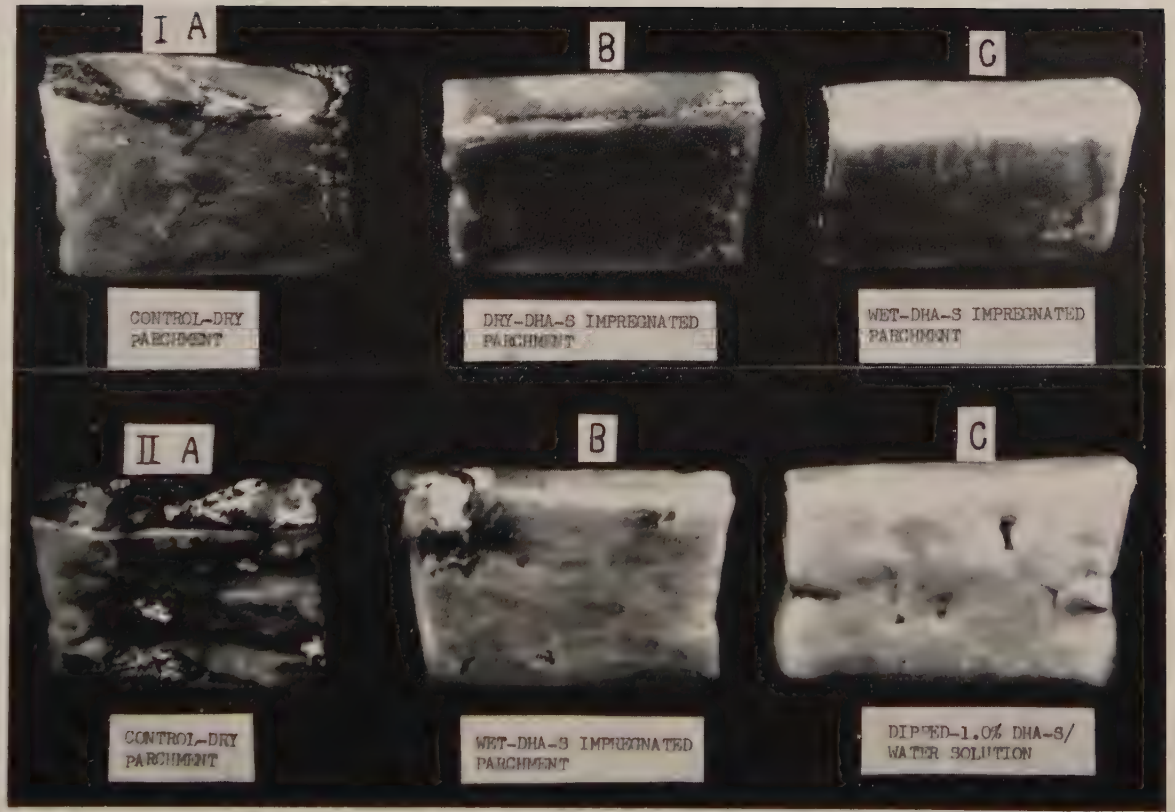


Fig. 7. Cheese samples shown here were treated as indicated and held for 14 days at approximately 10 C.

tions as mycostatic agents. Additional studies by Seevers *et al.* (1950), Shideman *et al.* 1950, and Woods, *et al.* (1950) relative to the general pharmacology, methods for estimation, and detoxication of DHA have made information available which will aid in the evaluation of the public health problems associated with the use of this compound.

TABLE 2—*Relative growth of surface mold on butter and cheese samples seeded with a suspension of mold spores*

Treatment of sample prior to storage	Butter			Cheese		
	14 days	28 days	42 days	14 days	28 days	56 days
1. Control-wrapped in dry parchment	++	+++	++++	+++	++++	++++
2. Wrapped in dry-DHA-S impregnated parchment	+	++	++++	++	+++	++++
3. Wrapped in wet-DHA-S impregnated parchment	−	+	+	+	++	+++
4. Sample dipped in 1.0% DHA-S/water solution. Wrapped with wet-DHA-S impregnated parchment	−	−−−−	−−−	−	−	+
5. Coated with paraffin	.....	.....	.....	−	−	± *
6. Coated with paraffin containing 0.5% DHA-S	.....	.....	.....	−	−	−

*Some growth at points of paraffin rupture.

As shown in Table 1 and Fig. 2 the specific activity of DHA and DHA-S as an inhibitor of mold growth is, apparently, mycostatic in nature. The antibiotic powers of these materials are manifested only as long as the concentrations are maintained at growth inhibiting levels. The concentration of DHA-S required to suppress mold growth during a seven day test period was inadequate as an inhibiting concentration for a 21-day test period. This observation might be accounted for on the basis that the mycostatic agent is either utilized by the mold or altered by the metabolic processes of the molds. Furthermore, one must not discount the possibility of accommodation by the test organisms. In practice, then, it would seem advisable to add DHA-S in concentrations slightly above that required to inhibit mold growth during the desired storage period. The cheese samples shown in Fig. 7 show clearly the superior keeping quality induced by the "dip" technique as a means of treating the samples with DHA-S. Quite possibly, this superiority in keeping quality might be accounted for on the basis that the DHA-S in solution is carried to all exposed surfaces; whereas, the "dry" and "wet" parchment wrappings were effective in suppressing surface-mold only on areas of surface contact.

In addition to the mycostatic activity derived from the use of DHA and DHA-S in butter and cheese coverings, certain benefits could be gained from using a one or two percent solution of DHA-S as a

post-cleaning rinse or spray for dairy plant equipment and walls. In this manner air-borne contamination might be partially controlled by depositing a mycostatic residue of DHA-S on all exposed surfaces. Such a conjecture could only be demonstrated by results obtained over an extended experimental period. Preliminary results, utilizing spraying and rinsing techniques as reported in this paper, indicate strongly the feasibility of such a practice.

SUMMARY

Low concentrations of the anti-microbial chemicals dehydroacetic acid (DHA) and its sodium salt (DHA-S) were effective growth inhibitors for the test organisms *Penicillium expansum*, *Penicillium roqueforti*, and *Rhizopus nigricans* on Czapek's mold agar.

The specific activity of these materials appeared to be mycostatic in nature.

One-percent water solutions of DHA-S, used as a dip or as an impregnating material for parchment wrappers, practically eliminated the growth of surface contaminating molds on butter and cheese during storage.

Results from preliminary trials indicate that a 1-percent DHA-S water solution, used as a spray on mold supporting surfaces, was effective in suppressing mold growth.

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A COMPARISON OF THE CHEMICAL AND MICROBIOLOGICAL METHODS FOR DETERMINING CYSTINE IN PROTEIN HYDROLYZATES

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A REVIEW OF WORK dealing with the metabolism of sulfur compounds by bacteria, indicates that some micro-organisms may be quite specific in their requirement for sulfur. Dunn and associates (1) have shown that cystine is required by the organism *Leuconostoc mesenteroides* P-60. Riesen *et al.* (2) have recently compared the requirements of various lactic acid bacteria for cystine and found that *Leuconostoc mesenteroides* P-60 was more specific in its response to this amino acid than any other organism tested. Lyman *et al.* (3) have found that the treatment of peptone with hydrogen peroxide results in the destruction of methionine, cystine, tryptophan and tyrosine. These authors (3) have used a simplified medium containing peroxide-treated peptone to demonstrate the response of *Leuconostoc mesenteroides* to methionine and tyrosine. Riesen *et al.* (2) reported higher acid production by this organism in a cystine-free medium containing peroxide-treated peptone and graded levels of cystine than was found in a medium containing either synthetic amino acids or an oxidized casein hydrolyzate. Heller and Kirch (4) have determined cystine, using a synthetic medium containing high proportions of arginine, alanine, and asparagine. The work of Riesen *et al.* (2) appeared during the time this investigation was in progress. The purpose of the present research has been a) to ascertain whether cystine can be determined microbiologically, b) to determine the cystine content of various protein hydrolyzates, and c) to compare the results obtained by a recognized chemical method with those obtained by a microbiological procedure.

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[2]The authors extend appreciation to Prof. C. D. Ball, of the Department of Chemistry for supplying some of the vegetable proteins.

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EXPERIMENTAL

Three different media were used. The composition of the first medium was essentially the same as that used by Lyman *et al.* (5) for the determination of methionine except that *l* (-)-cystine was replaced by an equivalent amount of *dl*-methionine. The second medium was similar to the first except that tyrosine was omitted. The third was the synthetic medium III of Sauberlich and Baumann (6) from which cystine was omitted. Acid production was measured titrimetrically after incubation for 72 hours at 37° C. The test organism, *Leuconostoc mesenteroides* P-60, was maintained on the medium described by Lyman *et al.* (5) Both animal and plant proteins were used as sources of protein hydrolyzates. These included casein, lactalbumin, bovine plasma albumin, zein, edestin (Hemp seed), squash seed globulin, and pumpkin seed globulin. The samples of proteins were hydrolyzed in 6N hydrochloric acid by autoclaving at 5 pounds pressure for 8 hours. In some cases, the samples were hydrolyzed by refluxing with 6N sulfuric acid for 8 hours. For the chemical determination, cystine was precipitated from the hydrochloric acid hydrolyzate as the cuprous mercaptide by the method of Csonka *et al.* (7). The cystine was determined by the Sullivan reaction as modified by Evans (8) using a Cenco Photelometer with filters No. 3385 and 4304.

RESULTS AND DISCUSSION

RESPONSE OF THE ORGANISM TO CYSTINE IN MEDIA OF VARYING COMPOSITION

Of the three different media used, the one containing hydrogen peroxide-treated peptone plus methionine, tryptophan and tyrosine as the source of amino nitrogen gave the best growth response, as is evident from curve 1 in Fig. I. Although Riesen *et al.* (2) did not report the use of tyrosine in the medium containing oxidized peptone, its use in this medium would seem to be quite essential (curve 2). On the other hand, the medium containing the individual amino acids did not promote satisfactory growth for the organism (curve 3). The superiority of using peroxide-treated peptone supplemented with methionine, tryptophan and tyrosine over the synthetic medium is thus obvious. Whether such a property of peptone is due to strepogenin or to strepogenin-like compounds has not been investigated.

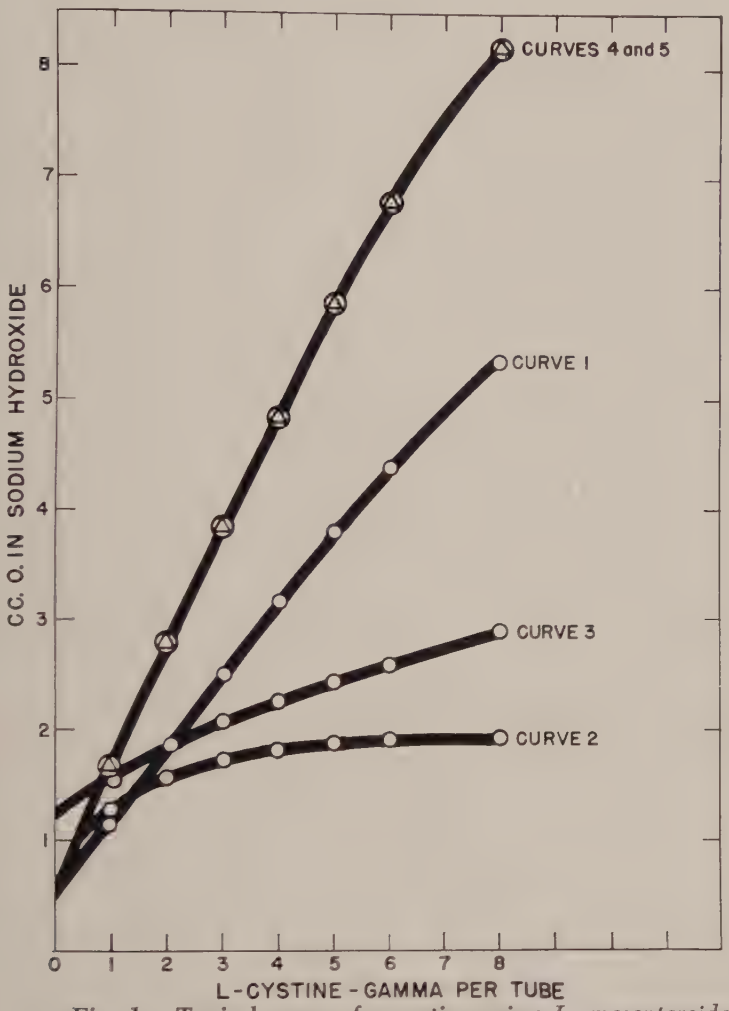

Fig. 1. Typical curves for cystine using *L. mesenteroides* and different media preparations. Curve 1, cystine standard-autoclaved with the medium containing oxidized peptone; curve 2, when that medium did not contain tyrosine; curve 3, cystine standard-autoclaved with the synthetic medium; curve 4, cystine standard-filtered aseptically and dispensed into autoclaved-medium containing oxidized peptone; curve 5, when sugar was filtered aseptically and dispensed into autoclaved-medium containing cystine standard and oxidized peptone.

EFFECT OF MEDIA PREPARATIONS ON THE GROWTH RESPONSE OF THE ORGANISM

In the foregoing procedures, graded levels of *l* (-)-cystine were added to the complete medium and sterilization was effected by autoclaving at 15 pounds pressure for 10 minutes. This was followed by inoculation and subsequent incubation. It was suspected that some loss of cystine would probobly take place because of the cystine-sugar combination at high temperatures. To avoid any possible reactions between cystine and sugar, two different procedures were adopted: 1) the standard cystine solution was dispersed aseptically after filtering through a Berkefeld or glass filter into tubes containing the complete medium, already autoclaved and cooled to room temperature; 2) the glucose solution was added aseptically after filtering through a Berkefeld filter into tubes containing sterilized incomplete medium and varying amounts of cystine. Curves 4 and 5 (Fig. 1), obtained according to procedures 1) and 2) above, indicate definitely that more acid was produced than when the complete medium was autoclaved with cystine. This led to the conclusion that cystine was destroyed or rendered unavailable as a result of autoclaving the standard and the medium together. The loss of cystine approached 50 percent at some levels. A standard curve obtained under these conditions might not give a true picture of the response of the added cystine. Similar findings also have been reported by Riesen *et al.* (2). The loss, however, is consistent as was indicated by a number of trials. It should be pointed out that the organism occasionally responded erratically under the two above-mentioned procedures, whereas no such phenomenon was noticed when cystine was autoclaved with the medium (curve 1).

Table 1 gives a comparison of the cystine values obtained from standard curves prepared under the three sets of conditions. The data indicate that the results are quite comparable. These results also show that cystine in the test materials was subject to a loss which was proportional to the loss occurring in the cystine standard when autoclaved in the presence of sugar in the medium. Thus the results obtained by the usual procedure are essentially the same irrespective of treatment. Since the filtration procedures are very tedious when dealing with a large number of test materials, the usual method of running the microbiological assay has been given preference.

TABLE 1—*Amount of cystine found in protein hydrolyzates prepared by three different procedures*

Procedure	Cystine per 100 grams of protein hydrolyzate			
	Casein	Lactalbumin	Zein	Edestin
	grams	*grams*	*grams*	*grams*
Standard and test materials autoclaved with the medium	0.22	2.28	.....	1.11
Standard and test materials autoclaved with the medium without sugar. Sugar added aseptically after filtration through a Berkefeld filter	0.23	2.33	0.21	1.19
Standard and test material added to autoclaved medium after aseptic filtration through a Berkefeld filter	0.24	2.40	0.22	1.20

TABLE 2—*Response of Leuconostoc mesenteroides P-60 at different levels of protein hydrolyzates and recovery tests obtained with cystine*

Protein	Hydrolyzate per tube	Cystine		Recovery tests				
				Cystine			Total recovered	
		Found	Per ml. hydrolyzate	In hydrolyzate	Added	Total	Found	
	ml.	*ug.*	*ug.*	*ug.*	*ug.*	*ug.*	*ug.*	%
Casein*	0.6	1.10	1.83	0.53	3.0	3.53	3.10	87.8
	1.0	1.95	1.95	1.06	2.0	3.06	3.00	98.0
	1.5	3.32	2.21	1.59	1.0	2.59	2.60	100.4
Average	.....	.....	2.00	.....	.....	.....	.....	95.4
Bovine plasma albumin†	0.5	2.60	5.20					
	1.0	5.23	5.23					
Average	.....	.....	5.22					
Zein*	0.25	2.18	8.72					
	0.50	4.43	8.86					
	1.00	8.67	8.67					
Average	.....	.....	8.75					
Edestin*	1.0	1.70	1.70	0.88	4.0	4.88	4.65	95.3
	1.5	2.60	1.73	1.31	2.0	3.31	2.85	86.1
	2.0	3.60	1.80	1.75	1.0	2.75	2.78	101.1
Average	.....	.....	1.74	.....	.....	.....	.....	94.2
Squash seed globulin	1.0	1.85	1.85	0.98	4.0	4.98	4.58	92.0
	1.5	2.95	1.97	1.46	2.0	3.46	3.35	96.8
	2.0	4.05	2.03	1.95	1.0	2.95	2.90	98.3
	3.0	5.88	1.96	.....	.....	.....	.....	.....
Average	.....	.....	1.95	.....	.....	.....	.....	95.7
Pumpkin seed globulin	1.0	1.60	1.60	0.83	4.0	4.83	4.80	99.4
	1.5	2.45	1.63	1.25	2.0	3.25	3.40	104.6
	2.0	3.48	1.74	1.66	1.0	2.66	2.90	109.0
	3.0	4.98	1.66	.....	.....	.....	.....	.....
Average	.....	.....	1.66	.....	.....	.....	.....	104.3

*Nutritional Biochemicals Corp.
†Armour.

RESPONSE OF THE ORGANISM AT DIFFERENT ASSAY LEVELS OF PROTEIN HYDROLYZATES AND THE RECOVERY OF ADDED CYSTINE

How far the cystine-sugar interaction or other unknown stimulatory or inhibitory factors from protein hydrolyzates, if any, can affect the results according to the usual procedure of autoclaving the medium and the standard or test materials together might be better understood from an examination of the data in Table 2. Assays were run at three to four different levels of each protein hydrolyzate, and recoveries of added cystine in varying amounts were observed. There was close agreement in the results as calculated from different levels in each case. The recovery of cystine, which varied from 94.2 to 104.3 percent (average variation), was quite satisfactory. This shows, therefore, the absence of any interfering agent in the protein hydrolyzates.

The results also indicate a proportional loss of cystine both in the standard and test materials, as has been mentioned before. The final check on these results has been on the basis of the chemical method for the determination of cystine. These results are shown in Table 3. A perusal of the data reveals that the chemical and microbiological methods give highly comparable values. It must be stated, however, that the values reported herein may not necessarily represent the true cystine content of the proteins since the method of hydrolysis was not controlled and some destruction of cystine may occur during hydrolysis. The primary purpose of the present investigation was to study the

TABLE 3—*Comparison of the chemical and microbiological methods*

Protein	Cystine per 100 grams of protein hydrolyzate	
	Chemical	Microbiological
	grams	*grams*
Casein*	0.26	0.23
Casein†	0.25	0.23
Lactalbumin‡	2.14	2.35
Bovine plasma albumin	5.44	5.22
Zein	0.19	0.18
Zein†	0.21	0.22
Edestin	0.89	0.88
Edestin†	1.08	1.15
Squash seed globulin	0.89	0.98
Pumpkin seed globulin	0.88	0.83
Casein†§		0.25
Casein†‖		0.32
Lactalbumin†§		2.22
Lactalbumin†‖		2.88

*Labco.
†Nutritional Biochemicals Corp.
‡Armour.
§Hydrolyzed by refluxing under nitrogen.
‖Hydrolyzed in 6N sulfuric acid.

possibility of using micro-organisms for the determination of cystine in protein hydrolyzates, rather than to report the absolute values for cystine in the various proteins. In this connection it may be stated that hydrolysis of casein and lactalbumin with 6N hydrochloric acid in an atmosphere of nitrogen gas did not prevent the hydrolytic destruction of cystine. On the other hand, hydrolysis with 6N sulfuric acid appeared to cause less destruction than hydrolysis with 6N hydrochloric acid. This point, however, requires further study with a number of samples.

SUMMARY

1. The response of *L. mesenteroides* P-60 to graded levels of *l* (-)-cystine in a basal medium containing oxidized peptone follows a definite pattern. Tyrosine, tryptophan and methionine are essential in the medium. Advantage has been taken of this fact to assay cystine in protein hydrolyzates.

2. It has been shown that even short-time autoclaving causes the degradation of some cystine when the medium contains glucose. The loss is proportional both in the standard and in the test materials. Although autoclaving affects cystine in the medium, it does not cause any erratic growth of the organism except that acid production is lowered.

3. A number of protein hydrolyzates prepared by acid hydrolysis from both animal and plant proteins have been assayed for their cystine content. Cystine values estimated microbiologically agree fairly well with those determined by a recognized chemical procedure.

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FARM MACHINERY AND FARM FINANCES

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Modern farming involves large quantities of power and machinery to do the farm work. Man is a poor source of power since he is capable of a sustained output of only about one-tenth of a horsepower. That is about the power rating of a kitchen food mixer. How can a farmer do all of his work with such a low power rating? The answer lies in his ability to control power rather than in the ability to produce power. He can control the work of other men or he can use mechanical sources of power.

High wages for farm labor and the development of new machines to do farm work have resulted in a rapid increase in farm mechanization. Increased mechanization has resulted in a rapid rise of farm machinery expense. This increase can be good or bad, depending on whether the income is increased or other expenses decreased sufficiently to offset the machinery expense. What effect has this increased mechanization had on the investment, expense, income, and efficiency on Michigan farms? Some indication can be found by studying reports of the farm business analysis project of the Department of Agricultural Economics. Records kept by about 1,000 cooperating farmers have been analyzed each year since 1929.

VARIATION WITHIN THE STATE

The following discussion covers data and relationships for the entire state. In general, the relationships hold true for all areas of the state, with the possible exception of the fruit areas, in which there has been more fluctuation in income and expenses and where machinery expense makes up a smaller proportion of the total expense on the farms.

There are some differences between the areas in the degree of the changes. For example, on a farm basis the average investment and average machinery expense is lower in the northern part of the state than in the southern part. However, since the farms are smaller in

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the north, the investment and expense per tillable acre are higher in the northern areas. This fact tends to accentuate the importance of machinery and its relationships to the total farm business in the northern part of the state.

MACHINERY INVESTMENT

The investment in machinery on the average farm in 1949 was nearly four times the investment in 1929. In the farm record book, farm machinery includes all machinery as well as tractors, trucks, and the farm share of the automobile. The machinery investment is the inventory value shown in the account book. For this reason, the investment figure shows the depreciated value of the machinery rather than the amount spent for the equipment when it was new.

The record summaries show a gradual decline in machinery investment during the early 1930's, from $1,315 per farm in 1929 to $1,030 in 1934 (Fig. 1). This decline was due mainly to a drop in prices and inventory values rather than a decline in the amount of equipment. Starting with 1935, there was a steady increase in the average machinery investment for the next 10 years, an increase from $1,030 in 1934 to $2,396 in 1944.

Since 1944, there has been a very rapid rise in machinery investment, with the 1949 average being $4,758 per farm. This rapid rise has been brought about both by an increase in machinery prices and an increase in the amount of equipment on the farms.

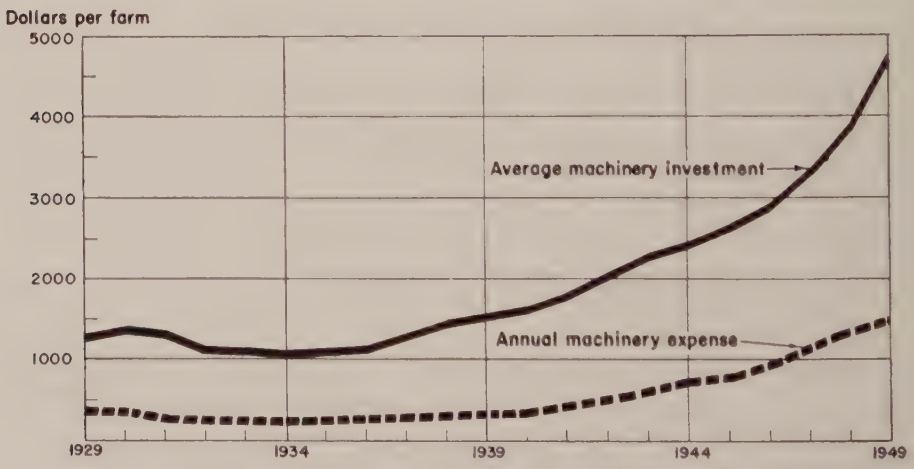

Fig. 1. Changes in machinery investment and expense per farm on Michigan farms, 1929-49.

During the 21-year period covered by the farm records, the average size of farm operated by the farm account cooperators increased from 107 to 136 tillable acres. The investment in farm equipment increased faster than the farm acreage; as a result, the investment per tillable acre increased from $12.29 in 1929 to $34.99 in 1949, or about a threefold increase in two decades. During the same period, the prices of farm machinery increased about 75 percent. If the machinery investment is adjusted to allow for the change in prices, the 1949 investment would be over $20 per tillable acre.

MACHINERY EXPENSE

Expense for farm machinery in the farm account reports includes depreciation and operating costs such as fuel and repairs. After a machine is purchased, the depreciation becomes a relatively fixed cost for the life of the machine. The operating costs will vary with the use and age of the machine. When a piece of machinery is purchased, some additional expense is added to the farm business. The machine is profitable in the farm business only if it increases the income or reduces the labor cost enough to offset this expense.

Equipment expenses stayed nearly the same on the accounting farms throughout the 1930's, but there has been a sharp rise during the 1940's. The two lines on Fig. 1 give the impression that machinery investment has risen more rapidly than machinery expense. It is true that more dollars have gone into the purchase of new machinery than into the expense of maintaining the machinery, but there is an other side to the picture that should be pointed out. By comparing the changes in investment and expense in relation to the period 1935-39, it is evident that machinery expenses have risen facter in recent years than have machinery investments (Fig. 2). This means that machinery expenses are greater for a given amount of machinery than they were in the pre-war years. During 1935-39, there were $23 of machinery expenses for each $100 of machinery investment. In 1949, machinery expenses were $32 for each $100 invested. Part of the rapid increase in machinery expense can be traced to larger and more expensive machines that add greatly to the depreciation charges. Part of the increase is due to more hours of use for tractors because of the elimination of horses, and the development of tractor equipment to do more farm jobs. Other reasons for the increase in expenses are the higher costs of repair parts and repair work.

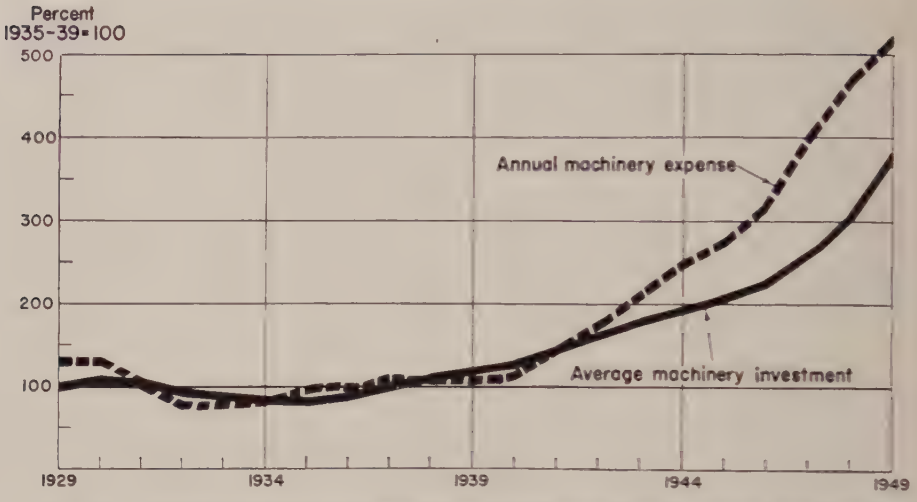

Fig. 2. Relative changes in machinery investment and expense per farm on Michigan farms, 1929-49.

MACHINERY EXPENSE AND TOTAL EXPENSE

Machinery expense has been one of the largest items of farm expense. In the discussion in this article, machinery expense is compared with the total of all farm expenses other than operator's labor and interest on investment. Thus, machinery expense is compared with the more variable expenses, such as feed purchased, seed, fertilizer, hired labor, and other operating expenses.

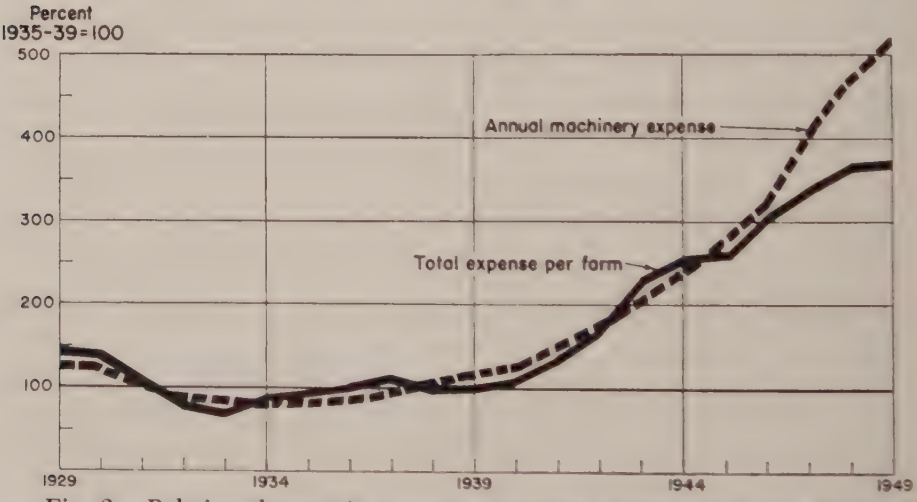

Fig. 3. Relative changes in average machinery expense and total expenses on Michigan farms, 1929-49.

In 1929, machinery expenses made up 19 percent of the farm expenses other than the operator's labor and interest on investment. During the depression years of the 1930's, machinery expense was more important in the expense picture, rising to 23 percent of the total in 1933. By the start of World War II, machinery expense had declined to about 20 percent and remained at about that level until after the end of the war. Since then machinery expenses have risen to 28 percent of the total farm expenses on Michigan farms.

A better way of showing the change in importance of machinery expense is an index with the prewar years 1935-39 as a base (Fig. 3). This figure indicates that since 1945 machinery expense has increased relatively more rapidly than total farm expenses. It has been pointed out that machinery expense increases when machinery is purchased, and this expense should be offset by increased income or a decrease in other costs. A high machinery expense on a farm can become burdensome unless the farm income remains at a relatively high level.

MACHINERY AND FARM INCOME

It is an established principle of farm economics that farm income fluctuates more widely than farm expenses. Farm machinery expense has been pointed out as one of the more fixed items of farm expense. For that reason, there is little relationship between the machinery expense for one year and the income for that same year. What relationship there is comes from the fact that farm equipment enables the farm operator to handle a larger volume of business, which results in higher total income.

There is an interesting relationship between machinery investment and net farm income that shows up in the records for Michigan farms. The investment in machinery per farm has averaged about the same as the net farm income over the past 20 years (Fig. 4). Net income has fluctuated more than machinery investment, but the general trend and the general level have been about the same. It is evident that in the last two or three years farmers have increased the investment in machinery more rapidly than usual in spite of a decline in net income. This may be explained in part by the fact that net farm income has been high for several years giving farmers more money to spend, and in part by the increased supply of farm machinery in the past few years.

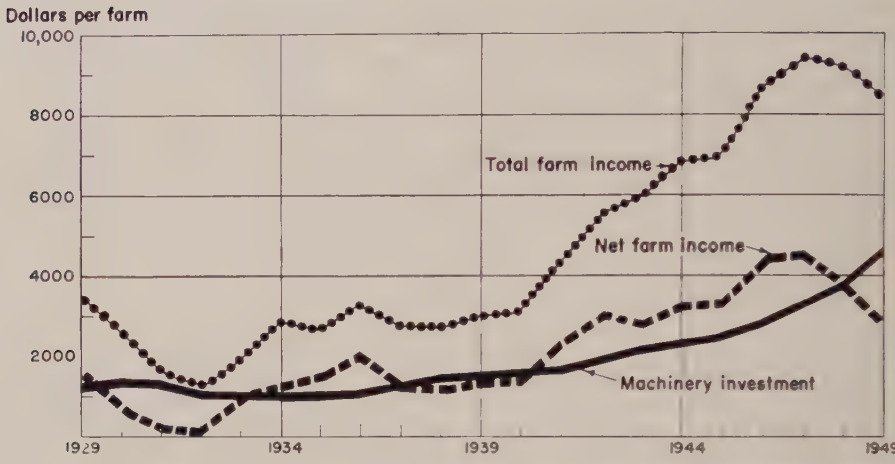

Fig. 4. Changes in average total income, net income and machinery investment on Michigan farms, 1929-49.

If the net income on these Michigan farms continued downward, the increased investment in equipment would present a problem of high expenses for depreciation and interest, even if the machinery operating expenses were reduced. Ordinarily this problem might be rather serious, but since it follows a period of high income with many farmers in a strong financial position there may be less danger at this time. Many farmers have paid for new machinery from past profits rather than from future income. Farmers who have recently started farming or have purchased large amounts of machinery for other reasons are in a less favorable position.

With a high level of economic activity in the nation and prospects of relatively high farm income for several years, a high investment in equipment may be an advantage. With high levels of employment and high wages, farm labor will be difficult to find and labor costs will be high. This does not mean that a high investment in machinery is good for all farms. Farmers with limited size of business cannot increase income or reduce other expense to meet the high cost of large equipment. However, a well equipped farm of adequate size should be able to reach a high level of production which will be profitable with the expected favorable price relationships.

MECHANIZATION AND EFFICIENCY

Mechanization of Michigan farms has been accompanied by changes in size and efficiency of the farms. In the 21 year period since 1929, the average size of farm in the farm accounting project has increased from 159 to 198 total acres, while the tillable acreage increased from 107 to 136 acres. Another measure of size, productive man work units, indicates the change in size of all production enterprises. (A productive man work unit is the amount of work accomplished by an average farm worker in a ten hour work day as of about the year 1932.) The productive man work units per farm have increased from 419 in 1932 to 477 in 1949. This increased size of business has been handled by a smaller labor force. As a result, the productive man work units per man have increased from 229 to 292. This means that the 1949 farm worker was able to accomplish an amount of work equal to the 1932 worker plus 63 more ten hour days of productive work in a year's time. This additional work has been done by increasing the amount of work accomplished in a given time rather than by increasing the days or hours worked. Evidence that the hours of work have decreased is found in reports of the United States Department of Agriculture which indicate that the average length of the work day has declined on Michigan farms from 12.3 hours in September 1939, to 11.6 hours in September 1949.

These measures indicate an increase in size of farm and labor efficiency on Michigan farms by supplementing man power with mechanical power and equipment. The greatest increase in mechanization has occurred in the last 10 years. The changes in size of farm and labor efficiency have not been as great as the increase in machinery used on farms (Fig. 5). Machinery investment per farm was 116 percent greater in 1949 than in the pre-war years 1935-39. Machinery expense was 168 percent higher. On the other side, the change in the measures of size and efficiency was only 20 to 30 percent. To make the comparison more valid, the effect of higher machinery prices and higher costs of repairs was removed before the percentages were calculated. The first conclusion might be that mechanization of Michigan farms has not been very effective. Closer study of the information indicates that the conclusion is misleading. The increase in efficiency during the past decade has been between 2 and 3 percent annually. Studies of agricultural production have indicated that an

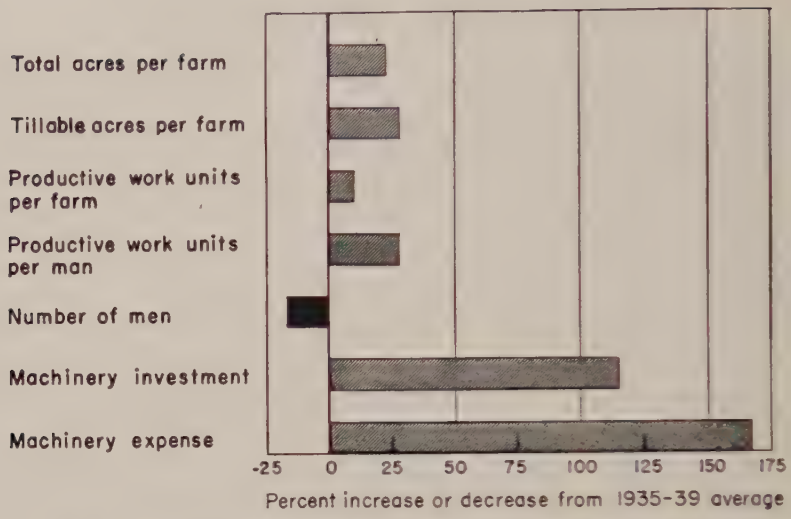

Fig. 5. Changes in size of farm, efficiency of labor, and machinery on Michigan farms, 1935-39 to 1949.

increase in efficiency of about 1 percent per year has been typical in American agriculture.

There are many reasons why changes in size of farm and efficiency do not follow the same trend as machinery investment. Changes in size of farm cannot be made rapidly resulting in the use of equipment below its full capacity. On many farms the labor force is made up of the farm family. A machine can speed up the work and make it easier, but the labor force cannot be reduced. Some machines may not be too efficient in doing the job for which they were designed. Mechanization has been greatest in field work and least in livestock work which is more important in Michigan agriculture. All of these factors reduce the effect of mechanization on efficiency of production.

The rapid increase in machinery investment in the last 5 years might be taken as an indication of potential increase in efficiency of labor on Michigan farms. Certainly Michigan farmers should be in a better position to meet a possible war situation and labor shortage than they were 10 years ago, following a period of lower incomes and with not much reserve of new farm equipment.

SUMMARY

Investment in farm equipment on Michigan farms has risen since 1935, with a very rapid rise in the last 5 years. Nearly four times as much investment in machinery is required to operate a farm now as compared with 20 years ago. Annual machinery expenses have risen more rapidly than other farm expenses in the past 10 years. A high machinery investment leads to a high depreciation expense. This could be dangerous on some farms, but in general, the rapid rise in investment followed a period of high income and farmers are in a stronger financial position to face future income changes. On most farms the increased machinery expense has been more than offset by increased income or decreases in other expenses.

A well equipped farm that has adequate size should be in a good position to enter a period of high production even in the face of labor shortages and high labor costs. Measures of size of farm and labor efficiency have shown an increase of between 20 and 30 percent in the past 10 years. The rapid increase in machinery investment might be taken as an indication of potential future increases in efficiency of Michigan farm production.

MOUSE POPULATIONS IN ORCHARDS AND A NEW METHOD OF CONTROL

By DON W. HAYNE
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AT THIS TIME of year every orchardist or nurseryman wonders whether mice[1] will attack his trees this fall and winter. If he is foresighted, he will already have looked for evidence of mouse activity and will now be planning or carrying out necessary control measures. Small piles of fresh cuttings of grass (the individual bits of grass about an inch long) and fresh mouse droppings in well developed runways

Fig. 1. Cuttings of fresh grass are characteristic of meadow mouse activity. Cuttings may be either in small piles or more scattered along the runways. Caution – distinguish between fresh cuttings and older work, since these bits of grass may persist for some time after being cut.

[1] *Microtus pennsylvanicus* Ord, the meadow mouse or vole.

ARTICLE 33-20

beneath overhanging grass are, in Michigan, almost sure signs of the presence of the meadow mouse (Fig. 1). Perhaps areas with the bark freshly removed on trees or shrubs offer warning that damage is already started and that control is vital to give protection before more harm is done.

What should be done about mice in orchards? Most important, every grower must examine his orchard periodically for evidence of mice and use control measures when evidence of activity indicates a growing or a high population. Information will be given here on changes in numbers of mice and also on a control method new in this state.

NUMBERS OF MICE

"Mouse years," or times of unusual abundance of meadow mice, have been recognized for many years. More recently it has been found that the number of mice rises and falls in a more or less regular cycle, with about four years between times of peak abundance. There is no general agreement as to the probable causes for this population behavior, although there has been much speculation. Suggestions have included epidemics of disease in the high populations, raids of predatory animals, periods of unfavorable weather, changes in reproductive rate, the effect of sun spots, periodic dietary deficiencies in the available food, and a population-wide exhaustion of certain hormone systems. One thing seems certain, that the periodic use of control measures in orchards is not responsible for the general population behavior, since the numbers of mice rise and fall in wild land just as markedly as in cultivated land.

Damage to trees by mice was unusually severe during the fall and winter of 1948-49 in this state. In the spring of 1949, through the courtesy of Mr. C. J. Borum, Agricultural Statistician, United States Department of Agriculture, an inquiry on damage done by mice was included in a questionnaire regularly sent to fruit growers at that season. The average loss reported in 117 replies was $68.29, ranging between no loss and a loss of $1,000. A similar questionnaire covering last winter (1949-50) showed an average of $26.51 based upon 133 replies. Several orchards reported having lost heavily both winters. These are minimum estimates since some growers included as losses only damaged trees which died while others included both the expense of bridge-grafting damaged trees and the annual expense of control measures. Perhaps no one can accurately estimate the reduced future

yield due to damage by mice. The average losses quoted above are probably somewhat below the true losses experienced.

A survey of the abundance of meadow mice has been carried on by the author in southern Michigan in spring and fall (May and September) since 1947. The results of this survey, as illustrated in Fig. 2,

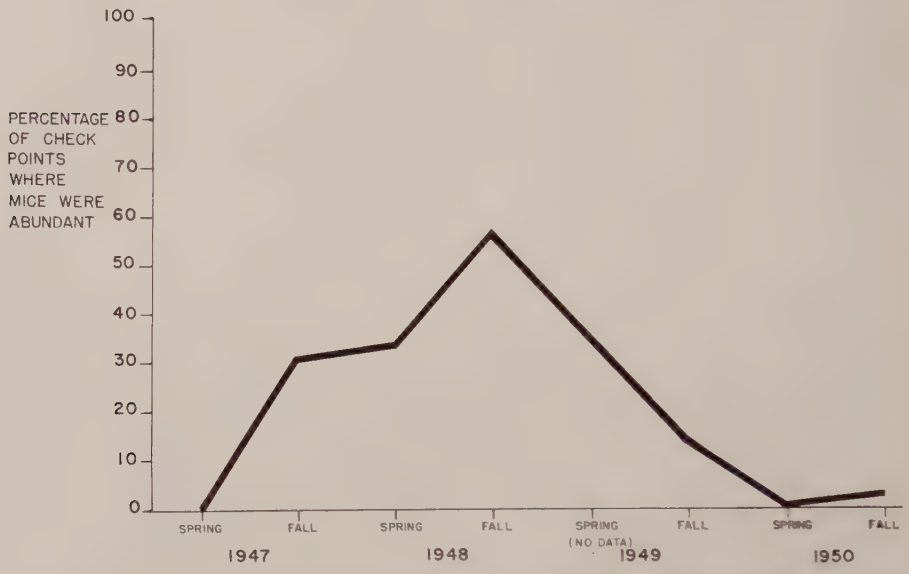

Fig. 2. Numbers of meadow mice follow a cycle, as shown here by the proportion of local populations where mice were abundant. This graph is based upon a twice-yearly visit to about 90 check points in southern Michigan. Danger of damage in an orchard depends largely upon the presence of an abundant population of mice.

show the general abundance of mice and may be used to estimate the state-wide hazard of damage to trees. It is very important to realize, however, that this survey cannot be used in judging the danger from mice in any particular orchard. Last winter, for example, although the general abundance of mice had decreased markedly from the previous winter, mice were still abundant at 15 percent of the points examined, and some orchardists experienced injury, even though the average loss was lower, and a smaller percentage of growers reported any damage.

The methods used in this survey of mouse abundance are very simple. Scattered along routes of travel, areas are chosen for accessibility and for meeting those conditions which favor the presence of a meadow mouse population. The identical area at each of these check points is examined each spring and fall, and the level of the mouse

population present is recorded according to the signs of activity. To insure uniformity from year to year, this rating of signs of activity is conducted according to a written series of grade descriptions.

The results of this survey are shown in one way in Fig. 2, which shows the percentage of points examined which were graded at or above a level more or less arbitrarily termed "abundant." The level chosen as "abundant" was grade 6 in the series of grades ranging from 0 through 10. At grade 6 signs of activity are moderately abundant and moderately heavy, but not present at every point examined throughout the area being graded. With an increasing population it is quite possible that damage would occur in populations which according to this arbitrary scale were rated at less than abundant in September.

A NEW METHOD OF MOUSE POISONING

Poisoning of meadow mice may be done by any of three methods which are in common use. The two older and better known methods are by use of strychnine-poisoned oats (Fig. 3) and zinc-phosphide-

Fig. 3. Using strychnine-poisoned oats with bait stations like this, about a tablespoonful of grain should be used in each station, with about 30 stations per acre, placed next to runways or in long grass. This station is a rolled strip of asphalt building paper tied with string.

Fig. 4. Chunks of apple, dusted with zinc phosphide rodenticide, should be distributed at a rate of 100 or more per acre. Since cut apple bait soon spoils, it must be placed in runways where mice will find it quickly. An ice pick is a handy tool in this work; some workers prefer a longer piece of sharpened wire.

poisoned apple cubes (Fig. 4). More recent and less widely known is the method of using zinc-phosphide-poisoned cracked corn, distributed with a hand garden seeder (Fig. 5) as devised by Dr. W. Robert Eadie of the Cornell Agricultural Experiment Station.[2]

By this method of mouse control the grain, carrying about 2 percent of zinc phosphide, is spread in the orchard with a hand seeder. The recommended rate of application is about 2 pounds per acre. The seeder is adjusted to lay from 10 to 20 kernels per linear foot, and must have the furrow opener and furrow closer removed or raised. The seeder is wheeled along the drip line of the trees, laying the poison in an area where the grass cover is heaviest and the signs of mouse activity are usually most apparent. The seeder should be shut off when crossing any spots bare of grass, both to prevent ground-feeding birds from eating the grain and to avoid wasting poison. Under normal conditions of grass growth in an orchard the grain soon sifts down through the grass to the ground below, where it is apparently soon found by the mice and probably quite well hidden from birds at the same time. The

[2]Eadie, W. Robert. 1949, "Cutting the Cost of Mouse Control," American Fruit Grower, October, pp. 11, 27.

Fig. 5. Spreading zinc-phosphide-poisoned cracked corn with a hand seeder is an effective and rapid method of distributing poisoned bait (see text for details). Because of danger to wildlife, distribute the poisoned grain only in long grass and shut off the seeder when passing over bare spots.

chief advantage of this method of mouse control is the reduced amount of labor required for poisoning an orchard.

The recommended formula and method for preparing the grain are:

Cracked corn	**100 pounds**
Zinc phosphide	**2 pounds**
Vegetable oil	**1 quart**
Methyl green dye	**½ ounce**

Mix together the zinc phosphide and the methyl green and then add the vegetable oil and stir this mixture into a smooth thin paste. The grain may now be treated on a flat surface, such as a concrete slab, using a hoe to turn and mix the grain while the oil mixture is poured slowly over the pile. This operation is somewhat like mixing concrete by hand, and if the small quantity of oil and poison is mixed carefully with the grain it is possible to obtain a uniform coating of the grain without wasting much on the surface beneath. Do the mixing in a well ventilated shed or in the open, since zinc phosphide may give off an extremely poisonous gas upon contact with an acid and the dry zinc phosphide is very toxic if inhaled as a dust. The poisoned grain must

be kept dry until used in the orchard, since it deteriorates when moist and loses its effectiveness.

The methyl green dye is said to discourage ground-feeding birds from eating the poisoned grain. When the grain is treated in the manner described above, the dye does not reveal its presence until the grain becomes moist, after being spread in the orchard, but then the grain takes on a bluish green cast, somewhat darkened by the grey zinc phosphide.

Cracked corn is often variable in size; in this method of mouse control the size should be fairly uniform. Satisfactory results were obtained in tests with corn of the size known as "coarse," but which did not contain whole kernels. If the cracked corn is too small, less than a lethal dose will adhere to a kernel, while if it is unnecessarily large the number of kernels per acre is smaller than necessary and the chances of a mouse encountering the poison are reduced. With this coarse cracked corn, about 2 pounds per acre were used when the seeder was operated in lines 20 feet apart, equivalent to both sides of each row of trees in a 40-foot planting. Satisfactory results were obtained when this rate of dosage was cut in half (lines 40 feet apart). In another test, the grain was distributed by gloved hand, using rubberized work gloves. The operator walked between two rows of trees, slinging a narrow swath of poisoned grain along the edge of mulch beneath a tree, into clumps of tall grass, and in other places where experience had taught that signs of mice were to be found. This last method of spreading poisoned grain by hand was most economical of time, and as effective as using the hand seeder. However, there is a tendency to use more than the specified 2 pounds per acre, and unless the operation is handled carefully, it would be possible to lay a dangerously large amount of the poisoned grain in one small spot, increasing the danger to birds. If this method of hand spreading is tried, it is recommended that the total amount of grain to be used in the orchard be divided into smaller quantities, each to be used in a part of the orchard, as in one trip across and back. This will prevent dangerously large quantities from being used in part of the orchard, leaving not enough for the rest.

EXPERIMENTAL WORK WITH ZINC PHOSPHIDE

The proposal of any new method for poisoning mice raises two questions. First, is the technique effective against the mice? Second, what are the hazards connected with the use of the new method?

Experimental work done at this station helps to answer these questions, and is mentioned briefly here.

Experimental trials were made of this and other control methods where meadow mice were captured alive, marked, and then released again. The experimental area was then poisoned using the recommended technique, and trapping was done again to discover the surviving animals. Three such trials using the zinc-phosphide-poisoned cracked corn showed survival of, respectively, 4, 12, and 11 percent of the marked adult animals. These results indicate very efficient control compared to the tests of the other methods. However, it must be pointed out that the three tests of this method were all carried out in 1949, a year of generally decreasing mouse populations (Fig. 2), and it is possible that the stage of the population cycle affects the efficiency of a control measure, especially with regard to invasion from neighboring populations following the poisoning of an area.

The labor required to poison an orchard by this new method was, on the average, much less than that by the other two methods. In the tests mentioned, about 10, 16, and 19 minutes per acre were used respectively. This time counts only the labor used in spreading the poison in the orchard and it does not include the mixing of the poison. From these tests it is apparent that the method is effective and efficient under Michigan orchard conditions.

Tests of the toxicity of zinc phosphide to pheasants were carried out, using birds supplied by the Game Division of the Michigan Department of Conservation. The tests showed that this chemical is highly toxic to pheasants. One could expect about half of any group of pheasants to die after eating 15 kernels of the poisoned coarse cracked corn used in the experiments mentioned above, while almost all would die of eating 45 kernels.

Tests of the rate of deterioration of poisoned grain exposed to weather under orchard conditions were carried out with the zinc-phosphide-poisoned cracked corn. This grain was exposed on shallow wooden trays beneath a cover crop, and samples were brought in periodically and dried. By tests using laboratory mice, the grain was found to retain about 56 percent of its toxicity after a week of weathering and about 20 percent after 4 weeks. During part of the period of weathering the grain was exposed to rain, and during much of the time it was covered by a wet snow. It must be concluded from these experiments that zinc phosphide is extremely toxic to pheasants, and that the toxicity does not disappear rapidly as a result of weathering.

DANGER TO WILDLIFE

As is true with all poisons used in orchard control of mice, there is probably some danger that wildlife may be poisoned accidentally when zinc phosphide is used. The tests on toxicity and rate of weathering mentioned above show the need for caution in distributing this very toxic material.

Although the green dye is said to repel birds, this claim has not been confirmed for all birds or under Michigan conditions. To be on the safe side, the method of poisoning should be used only in orchards under sod, where the bait should be distributed only in long grass and never on bare areas such as roads. No more than the recommended 2 pounds per acre should be used.

Some reassurance as to danger to wildlife may be drawn from the fact that no casualties to wildlife have been reported in Michigan following scattered use of the method. In New York State, after the method was used on over 10,000 acres of orchards, Dr. Eadie stated,[3] "There is no evidence that this new method of baiting orchards for mouse control presents any serious hazard to wildlife when properly used." On the other hand, he also mentioned finding cottontail rabbits which may have died from eating mouse bait. The present author has observed in Michigan the accidental poisoning of cottontails through improper use of strychnine-poisoned oats in tin-can stations. Careless use of any poison may result in the poisoning of wildlife as well as poultry, live stock, and pets, or even humans.

SUMMARY

Although the meadow mice in Michigan seem to follow a regular cycle in abundance, local populations are often not "in step" with the state-wide trend. Therefore, it is necessary that each orchard be inspected for the presence of mice, even in times of generally low abundance.

Poisoning orchard mice with zinc-phosphide-poisoned cracked corn distributed by a hand seeder is an effective control measure and requires less labor than other methods. As with all poisons there is some danger to wildlife. The bait must be distributed only in spots protected by good cover, both to avoid accidental poisoning of other forms of life and to present the bait directly to the mice.

[3]Eadie, W. Robert. 1950, "New Techniques in Control of Orchard Mice," Cornell Univ. Agr. Exp. Sta. Bul., 856:1-16.

MICHIGAN FARM BUSINESS REPORT FOR 1949

By W. H. VINCENT, J. C. DONETH and E. M. ELWOOD
DEPARTMENT OF AGRICULTURAL ECONOMICS

WHAT RETURNS can be expected from farming? What changes are taking place in farm organization? What are the characteristics of different type-of-farming areas of Michigan? Questions of this type are being answered by Michigan farmers through a continuous farm record-keeping project in cooperation with the Department of Agricultural Economics and their own county agricultural agents.

Average results by years since 1929 are available for the state as well as for individual type-of-farming areas. This report will summarize some items over a 21-year period but will present in greater detail the results of the records in 1949.

FARM EARNINGS

Farm earnings in 1949 on these 912 record-keeping farms averaged their lowest since 1941. The average labor income in 1949 was $1,815 per farm operator, compared with $2,735 in 1948 and $1,282 for the 1929-49 average. (Labor income represents what the farm operator receives for his labor, management, and business risks incurred during the year. In addition, the farm operator receives the value of farm products used from the farm in the home.)

TABLE 1—*Farm earnings on farm accounting farms in Michigan by years, 1929-49*

Year	Labor income	Year	Labor income
1929	$585	1939	$780
1930	−263	1940	787
1931	−676	1941	1,675
1932	−595	1942	2,303
1933	249	1943	1,990
1934	565	1944	2,406
1935	764	1945	2,483
1936	1,318	1946	3,374
1937	569	1947	3,486
1938	571	1948	2,735
		1949	1,815
21-year average (1929-49)			$1,282

Most of the decline was due to lower farm prices. The prices received by farmers in 1949 averaged 6 percent less than in 1948, with especially notable reductions in prices during the summer and fall marketing months. The effect was a $700 lower gross income per farm on these farms. This reduction, associated with constant total expenses and a higher total farm investment explains the marked reduction in labor income. A drop in income from 1948 can be noted in Table 2 for every major enterprise.

TABLE 2—*Comparison of gross income, expenses and labor incomes on farm accounting farms in Michigan, 1935-39 average, and by years 1945-49*

Item	1935-39	1945	1946	1947	1948	1949
INCOME						
Crops	$881	$1,948	$2,641	$2,663	$2,223	$2,085
Dairy products	910	2,782	3,366	3,456	3,671	3,274
Cattle	338	727	894	1,082	1,209	1,094
Hogs	224	538	748	949	725	643
Poultry and eggs	256	744	711	805	827	782
Sheep	112	102	137	126	102	104
Other	161	214	221	351	415	387
	$2,882	$7,055	$8,718	$9,432	$9,172	$8,369
EXPENSES						
Feed bought	261	889	921	1,231	1,190	1,062
Machinery	291	793	922	1,162	1,365	1,497
Hired labor	231	557	767	634	665	628
Crop expense	193	544	741	770	863	877
Family labor	197	386	418	468	509	469
Improvements	138	247	317	349	373	422
Taxes	74	103	118	128	138	146
Other	56	177	209	216	215	285
	$1,441	$3,696	$4,413	$4,958	$5,358	$5,386
Net farm income	1,441	3,359	4,305	4,474	3,814	2,983
Interest on investment at 5%	641	876	931	988	1,079	1,168
LABOR INCOME	$800	$2,483	$3,374	$3,486	$2,735	$1,815

The income decline was general throughout Michigan. This change as well as other financial data may be compared by type-of-farming areas in Table 4. (See Fig. 1 for location of various type-of-farming areas.)

HOW MUCH CAPITAL IS NEEDED TO FARM?

The amount of money needed to farm has increased markedly in recent years. The total farm investment has increased an average of $1,200 every year since the end of World War II. With greater use of large farm equipment this trend will likely continue. The average Michigan farm investment in 1949 totaled $23,346, including about $12,000 for real estate and the remainder on personal property (Table 4). The real estate is valued conservatively according to current prices.

These low values may be attributed to the fact that farmers are advised to maintain constant "normal" values on land and conservative values on other real estate. If these figures were adjusted to current prices the total farm investment would exceed $35,000 with about two-thirds of this amount in real estate. Other investments in 1949 included an average of $4,758 in machinery and equipment, $3,539 in livestock, and $2,482 in feed and growing crops. Variations in investments by type-of-farming areas may be noted in Table 4.

We now turn from the more or less fixed capital requirements in farm investments to the requirements in farm operating expenses. The operating expenses, (including a charge for the operator's labor), on Michigan farms today are twice the entire intake of money and over three times the amount of expenses during the five-year pre-war period, 1935-39 (Table 2). The greatest change has taken place in machinery expenses. Before the war, machinery expenses comprised only about 15 percent of total farm expenses, but they had increased to 22 percent in 1949. The apparent substitution of machines for men can be seen by noting that while machinery expenses have increased as a share of total expenses, labor expenses have decreased from 48 percent of the total during 1935-39 to 37 percent in 1949. This emphasizes that for the person starting to farm, a higher percentage of the budget must be planned for machinery operation than if he had started to farm 15 years ago.

Further evidence of the substitution of machines for labor is noted in the comparison of the number of men and the amount of work accomplished per man on these farms. There was the equivalent of 1.9 men per farm in pre-war years, but this has been reduced to 1.7 men per farm at present. (Approximately two and one-half months less available labor.) At the same time farm size has increased from 162 to 198 acres per farm, and productive man work units per man have increased from 228 to 292 (Table 3). The labor efficiency then, was

TABLE 3—*Comparison of size of farm, amount of livestock and amount of work, 1935-39 average and 1945-49 by years, Michigan*

Item	1935-39	1945	1946	1947	1948	1949
Number of farms	1,150	939	838	830	846	912
Total acres	162	195	195	193	196	198
Tillable acres	107	131	133	134	136	136
Productive animal units	20.8	26.5	27.8	27.1	23.9	25.6
Productive man work units*	427	490	498	473	466	477
Number of men*	1.9	1.7	1.8	1.7	1.7	1.7
Work units per man*	228	286	284	286	281	292

*Fruit farms excluded.

not increased by added machinery alone, but by an expanded business in both acres of work land and in amounts of livestock. Increased machinery and increased size of business are probably each stimulated by the other.

Another important expense item is the purchase of feed. In some years it will amount to one-fifth of all farm expenses. In 1949 it amounted to 18 percent of total farm expenses, compared with 13 percent for the 1935-39 period, owing in part to more livestock. This item has been minimized on some farms by adequate production of feed grains and maximum growth of high quality roughages.

The expenses involved in crop production (seed, fertilizer, crop harvesting, etc.) amounted to $877. Reductions in the outlay for fertilizers and seeds would probably result in a much greater reduction in the total value of crops produced. We conclude from experimental evidence that on most farms there is a need for greater expenditures in this regard rather than less.

Most of the other items are of a more fixed nature. In other words, they do not change substantially with increases or decreases in production. In 1949 these items amounted to $853. Since they are relatively fixed, the important consideration is to maximize production and spread these costs over as wide a base as possible.

As a summary of the capital requirements in farming, these 912 records have pointed out a total farm investment of $23,346 using "normal" values on real estate and breeding livestock (exceeding $35,000 at present values). It may be added that the inventories show only the undepreciated values which makes the total investment show considerably less than replacement cost. The operating expenses on these farms averaged $6,804 per farm of which 77 percent was made up by labor, machinery, and feed expenses.

TABLE 4—*Financial summary of 912 Michigan farms by type-of-farming areas, 1949*

Number of farms	All farms	Type-of-farming areas															
		1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17
	912	97	69	24	52	171	38	33	75	41	60	22	54	54	44	19	59
Total acres	198	202	219	108	160	223	214	221	163	216	221	185	234	186	172	176	166
Percent of farm acres tillable	69	76	80	80	76	75	75	77	76	53	62	70	72	49	70	45	42
Tillable acres	136	153	175	86	122	167	161	171	124	115	138	129	134	92	120	79	70
Real estate (less house)	$12,567	$14,351	$13,984	$16,820	$11,063	$16,229	$16,263	$14,722	$15,039	$ 9,416	$11,598	$22,984	$ 8,074	$ 7,140	$ 5,429	$ 7,998	$ 5,470
Machinery and equipment	4,758	5,125	4,594	4,518	4,849	5,708	5,575	5,972	5,230	4,080	4,853	7,309	4,082	3,075	2,695	3,920	3,198
Livestock (including horses)	3,539	4,662	4,090	1,511	3,726	5,063	4,483	4,473	3,221	3,428	3,254	1,968	2,184	2,065	1,568	2,684	1,766
Feed and crops	2,482	3,785	2,891	1,449	2,232	3,444	2,792	2,927	3,028	1,558	2,010	2,272	1,901	1,057	958	1,080	1,205
Capital investment	$23,346	$27,923	$25,559	$24,298	$21,870	$30,444	$29,113	$28,094	$26,518	$18,482	$21,715	$34,533	$16,241	$13,337	$10,650	$15,682	$11,639
Livestock income	$ 5,897	$ 7,470	$ 7,556	$ 2,327	$ 7,608	$ 7,895	$ 7,398	$ 6,909	$ 6,023	$ 4,726	$ 5,788	$ 2,785	$ 3,606	$ 3,246	$ 2,411	$ 5,579	$ 3,140
Crop income	2,085	1,844	2,139	6,870	1,352	2,119	2,569	2,766	3,297	406	1,651	10,355	1,823	905	565	173	376
Other income	387	370	415	412	392	554	322	508	362	352	400	576	264	132	254	416	395
Gross income	$ 8,369	$ 9,684	$10,110	$ 9,609	$ 9,352	$10,568	$10,289	$10,183	$ 9,682	$ 5,484	$ 7,839	$13,716	$ 5,693	$ 4,283	$ 3,230	$ 6,168	$ 3,911
Total expenses*	5,386	6,210	6,672	8,116	6,331	6,399	6,299	6,235	5,401	3,629	5,190	10,138	4,008	2,698	2,121	3,759	3,020
Net farm income	$ 2,983	$ 3,474	$ 3,438	$ 1,493	$ 3,021	$ 4,169	$ 3,990	$ 3,984	$ 4,281	$ 1,855	$ 2,649	$ 3,578	$ 1,685	$ 1,585	$ 1,109	$ 2,409	$ 891
Less interest @ 5%	1,168	1,395	1,278	1,214	1,094	1,522	1,456	1,405	1,326	925	1,085	1,727	812	668	533	784	582
Labor income, 1949	1,815	2,079	2,160	279	1,927	2,647	2,534	2,543	2,955	930	1,564	1,851	873	917	576	1,625	309
Labor income, 1948	2,735	3,954	2,903	602	2,930	3,014	3,042	3,267	3,777	2,482	2,517	3,321	2,000	1,233	1,491	2,960	1,657
Labor income, 1947	3,486	4,596	4,300	1,304	3,753	4,710	3,793	2,720	4,501	2,310	2,391	2,555	1,617	2,094	2,355	3,050	1,668
Labor income, 1946	3,374	4,337	3,169	4,378	3,011	3,312	2,988	3,585	4,413	2,489	2,485	7,635	2,221	2,066	2,267	2,954	2,357
Labor income, 1945	2,483	3,432	2,464	1,434	2,710	3,228	2,807	2,181	2,978	1,514	2,226	2,667	1,554	1,613	1,345	1,766	1,653
Labor income, 1944	2,406	2,719	1,452	3,536	2,409	2,496	2,712	2,753	2,940	1,815	2,393	5,831	1,819	1,613	1,661	1,850	1,551
Labor income, 1943	1,990	2,235	2,473	4,475	2,101	2,222	2,378	1,502	2,272	929	1,704	3,590	1,380	1,098	670	1,683	1,080
Labor income, 1942	2,303	3,056	2,389	2,637	2,142	2,763	2,856	2,673	2,543	1,636	2,330	2,806	1,489	1,253	1,346	1,601	1,193

*Includes family labor, but not operator's labor or interest on investment.

TABLE 5—*Kinds of crops and percentage of tillable land in different crops and also yields by type-of-farming areas in Michigan, 1949*

Number of farms	All farms	Type-of-farming areas															
		1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17
	912	97	69	24	52	171	38	33	75	41	60	22	54	54	44	19	59
No. of tillable acres	136	153	175	86	122	167	161	171	124	115	138	129	134	92	120	79	70
Percent in sod crops	43	34	41	21	34	40	41	44	29	54	49	28	51	54	59	64	71
Percent in legumes	30	28	30	14	27	31	34	33	27	36	37	18	29	33	36	49	21
Percent tillable acres in:																	
Tillable pasture	17	12	19	8	14	18	18	20	12	25	20	13	21	18	13	18	13
Alfalfa hay	12	9	13	10	10	13	12	11	11	16	13	6	11	16	2	25	4
Other hay	14	13	9	3	10	9	11	13	6	13	16	9	19	20	44	21	54
Corn (includes silage)	17	27	21	12	23	22	17	8	17	14	14	6	10	5	.....	14	.....
Wheat	12	15	18	6	17	14	13	11	15	6	9	6	5	9	6	1	1
Oats (oat mixtures)	15	18	14	7	17	16	19	15	14	16	14	6	14	14	14	17	17
Barley	1	1	1	.....	2	1	1	.....	3	1	.....	.....	.....	5	.....	3	1
Beans	2	.....	.....	.....	.....	.....	3	10	12	2	1	.....	.....	.....	.....	.....	.....
Sugar beets	1	.....	.....	.....	.....	1	.....	3	5	.....	.....	.....	.....	.....	.....	.....	.....
Potatoes	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	5	2	.....	1	4
Fruit and truck	2	.....	.....	44	.....	.....	.....	.....	.....	.....	.....	44	.....	.....	.....	.....	.....
Other	3	2	2	3	4	2	4	6	3	3	6	2	8	4	17	.....	3
Idle	3	2	2	7	2	3	2	3	2	4	5	8	7	6	3	.....	3
Seeds	.....	1	1	.....	1	1	.....	.....	.....	.....	.....	.....	.....	1	1	.....	.....
Crop yield per acre:																	
Alfalfa hay	1.9	2.0	1.7	2.3	1.7	2.2	2.0	2.2	2.5	1.6	1.7	1.8	1.4	1.6	1.6	1.8	1.8
Other hay	1.3	1.4	1.2	1.3	1.4	1.5	1.3	1.7	1.5	1.4	1.4	1.4	1.0	1.1	1.1	1.7	1.1
Corn, silage	10.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Corn shelled	54	55	48	55	59	57	55	65	62	41	51	54	36	36	.....	.....	.....
Wheat	28	30	24	35	25	29	30	33	33	27	26	29	16	23	17	27	20
Oats	38	43	40	40	41	39	34	42	41	34	32	.....	33	33	26	47	32
Barley	29	29	39	.....	45	29	22	.....	.....	20	.....	.....	.....	22	.....	31	30
Beans	20	.....	.....	.....	.....	.....	20	20	22	13	17	.....	.....	.....	.....	.....	.....
Sugar beets	9.6	.....	.....	.....	.....	6.4	.....	8.2	10.5	.....	.....	.....	.....	.....	.....	.....	.....
Potatoes	224	.....	.....	.....	.....	.....	.....	.....	.....	.....	252	.....	208	234	.....	275	268
Crop yield index	100	106	93	110	102	106	100	108	115	87	94	106	77	83	81	110	89
Crop sales and PMA payments	$ 1,984	$ 1,873	$ 1,787	$ 6,885	$ 1,605	$ 1,795	$ 2,354	$ 2,610	$ 3,398	$ 556	$ 1,479	$10,454	$ 1,691	$ 834	$ 676	$ 220	$ 641
Crop income total	2,085	1,844	2,139	6,870	1,352	2,119	2,569	2,766	3,297	406	1,651	10,355	1,823	905	565	201	376
Feed bought	1,062	1,412	1,809	812	2,123	1,259	1,028	947	924	580	991	653	519	467	335	1,023	624

TABLE 6—*Livestock: Kinds, amounts and returns from livestock by type-of-farming areas in Michigan, 1949*

Number of farms	All farms	Type-of-farming areas															
		1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17
	912	97	69	24	52	171	38	33	75	41	60	22	54	54	44	19	59
Livestock income, total	$ 5,897	$ 7,470	$ 7,566	$ 2,327	$ 7,608	$ 7,895	$ 7,398	$ 6,909	$ 6,023	$ 4,726	$ 5,788	$ 2,785	$ 3,606	$ 3,246	$ 2,411	$ 5,579	$ 3,140
Livestock income per T.A.*	43.39	48.70	43.15	48.53	62.57	47.22	45.90	40.31	48.44	41.17	41.84	38.04	26.99	35.20	20.17	70.53	45.08
Productive animal units	25.6	31.6	34.0	9.9	26.5	33.8	27.8	28.9	24.6	24.6	24.7	11.7	18.6	18.5	11.7	23.7	16.0
Tillable acres per P.A.U.**	5.3	4.9	5.1	4.9	4.6	5.0	5.8	5.9	5.0	4.7	5.6	6.2	7.2	5.0	10.2	3.3	4.4
CATTLE:																	
Percent farms reporting	97	97	97	67	98	97	100	100	100	100	100	86	100	100	95	100	100
Cows per farm reporting	12.6	12.3	13.8	6.3	13.5	15.1	16.0	16.0	12.2	12.3	13.4	7.3	10.2	9.5	7.1	16.8	11.4
Dairy sales per cow	$ 266	$ 292	$ 278	$ 247	$ 272	$ 302	$ 329	$ 299	$ 283	$ 203	$ 252	$ 224	$ 199	$ 158	$ 188	$ 255	$ 212
Dairy sales per farm reporting	3,362	3,481	3,828	1,551	3,667	4,550	5,249	4,779	3,464	2,488	3,382	1,642	2,039	1,507	1,327	4,282	2,415
Income per farm reporting	1,123	1,225	1,054	816	1,002	1,389	1,152	1,704	1,193	1,550	1,188	695	766	1,143	486	923	586
HOGS:																	
Percent farms reporting	60	82	70	.....	52	67	29	18	67	68	55	.....	80	80	66	32	19
Sows per farm reporting	2.8	4.4	5.3	.....	1.9	4.3	2.0	***	2.3	1.8	1.3	.....	1.2	1.1	***	***	***
Litters farrowed per farm	4.7	7.8	9.8	.....	2.7	7.0	3.8	***	4.0	2.1	2.3	.....	2.0	1.6	***	***	***
Pigs weaned per litter	6.6	6.1	6.5	.....	6.0	6.6	7.2	***	6.9	6.9	7.7	.....	7.3	7.5	***	***	***
Hog income per litter	227	229	231	.....	235	223	220	***	249	263	315	.....	173	166	***	***	***
Income per farm reporting	$ 1,075	$ 1,746	$ 2,270	.....	$ 645	$ 1,569	$ 840	$ 233	$ 1,003	$ 544	$ 725	.....	$ 354	$ 269	$ 44	$ 101	$ 9
SHEEP:																	
Percent farms reporting	12	13	22	.....	.....	26	8	6	8	10	.....	.....	13	11	5	5	2
Ewes per farm reporting	38	31	39	.....	.....	45	46	15	21	24	.....	.....	66	19	26	***	***
Lambs raised per 100 ewes	92	76	102	.....	.....	89	104	117	105	107	.....	.....	89	109	110	***	***
Sheep income per ewe	24	25	23	.....	.....	22	39	18	28	32	.....	.....	21	23	27	***	***
Income per farm reporting	$ 902	$ 789	$ 913	.....	.....	$ 1,017	$ 1,789	$ 281	$ 589	758	.....	.....	$ 1,178	$ 445	$ 710	$ 23	$ 25
POULTRY:																	
Percent of farms reporting	74	84	77	62	87	75	76	64	85	63	67	55	72	81	91	74	44
Hens per farm reporting	135	167	154	95	352	138	97	109	118	61	153	167	67	58	89	82	55
Egg sales per hen	$ 5 94	$ 6.33	$ 6.69	$ 6.29	$ 7.15	$ 5.92	$ 6.44	$ 4.52	$ 5.01	$ 4.30	$ 5.73	$ 6.23	$ 4.03	$ 4.16	$ 5.90	$ 4.59	$ 5.02
Egg sales per farm reporting	801	1,021	1,033	599	2,519	817	623	493	588	264	879	1,039	269	242	527	378	278
Income per farm reporting	253	344	321	256	584	272	180	83	175	119	349	159	239	151	154	69	33

*T.A. Tillable Acres **P.A.U. — Productive Animal Units ***Data not comparable

TABLE 7—*Expenses and efficiency factors, labor, machinery, improvements and other costs by type-of-farming areas in Michigan, 1949*

Number of farms	All farms	Type-of-farming areas															
		1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17
	912	97	69	24	52	171	38	33	75	41	60	22	54	54	44	19	59
Gross income per T.A.	$ 61.59	$ 63.12	$ 57.74	$112.25	$ 76.91	$ 63.21	$ 63.85	$ 59.41	$ 77.84	$ 47.75	$ 56.68	$106.06	$ 42.61	$ 46.46	$ 27.02	$ 78.00	$ 56.16
Total expenses per T.A.*	50.07	50 20	46 62	110.93	64.05	47.25	48.41	44.79	55.29	43.04	47.77	89.34	39.58	43.44	28.69	63 73	61.11
Total expenses*	6,804	7,702	8,164	9,497	7,788	7,899	7,801	7,677	6,877	4,941	6,608	11,552	5,287	4,004	3,430	5,041	4,258
Man labor:																	
Number of men†	1 7	1.6	1 6	2.5	1.6	1.7	1.9	1.9	1.7	1.5	1.8	3.3	1.7	1.5	1.2	1.5	1.5
Income per man	$ 4,939	$ 5,889	$ 6,152	$ 3,844	$ 5,845	$ 6,233	$ 5,561	$ 5,446	$ 5,781	$ 3,586	$ 4,463	$ 4,117	$ 3,201	$ 2,946	$ 2,651	$ 4,098	$ 2,585
Days of work per man†	292	331	343	. . .	324	342	286	293	288	262	271	. . . .	242	210	212	284	199
Hired	$ 628	$ 560	$ 558	$ 2,235	$ 740	$ 658	$ 876	$ 668	$ 438	$ 207	$ 563	$ 3,246	$ 481	$ 250	$ 152	$ 409	$ 335
Family	469	504	475	449	363	480	492	703	609	466	588	583	408	350	174	301	437
Operator	1,418	1,492	1,492	1,381	1,457	1,500	1,502	1,442	1,476	1,312	1,418	1,414	1,279	1,306	1,309	1,282	1,238
Expense per T.A.	18 51	16 66	14 42	47.48	21.06	15.78	17 81	16.41	20.29	17.29	18.58	40.55	16.23	20 68	13.67	25 18	28.85
Power and machinery:																	
% farms without horses	69	85	81	67	54	78	74	48	83	66	60	45	63	48	48	53	69
Investments	$ 4,758	$ 5,125	$ 4,594	$ 4,518	$ 4,849	$ 5,708	$ 5,575	$ 5,972	$ 5,230	$ 4,080	$ 4,853	$ 7,309	$ 4,082	$ 3,075	$ 2,695	$ 3,920	$ 3,198
Income per $1000 investment	1.759	1,889	2.201	2,127	1.929	1,851	1,845	1,705	1,851	1,344	1,615	1,876	1,395	1,393	1,198	1,574	1,223
Annual expense	1,497	1,765	1,656	1,627	1,388	1,789	1,746	2,010	1,706	1,222	1,415	2,138	1,264	855	792	1,030	865
Expense per T.A.	11 02	11 51	9 45	19 01	11 41	10 70	10 84	11.72	13.71	10.64	10.23	16.53	9.46	9.28	6.63	13.02	12.41
Improvements:																	
Investment	$ 5,769	$ 6,896	$ 6,151	$ 5,360	$ 5,661	$ 7,881	$ 7,349	$ 6,331	$ 6,634	$ 4,302	$ 5,419	$ 9,443	$ 3,353	$ 3,194	$ 2,303	$ 4,172	$ 2,855
Investment per A.U.	226	247	179		207	230	260	212	266	170	213		174	166	184	171	175
Income per $1000 investment	1,451	1,404	1,644	1,793	1,652	1,341	1,400	1,608	1,459	1,263	1,447	1,452	1,577	1,341	1,403	1,479	1,370
Annual expense	422	490	504	480	409	607	492	425	495	333	372	524	265	185	163	271	202
Expense per T.A.	3 10	3 19	2 88	5 61	3 36	3 63	3 06	2 50	3 98	2.90	2.68	4.05	1.98	2.01	1.36	3.43	2.90
Feed bought	$ 1,062	$ 1,412	$ 1,809	$ 812	$ 2,123	$ 1,259	$ 1,028	$ 947	$ 924	$ 580	$ 991	$ 653	$ 519	$ 467	$ 335	$ 1,023	$ 624
Crop expense	721	758	924	1,849	663	819	870	759	624	359	704	2,399	660	305	244	344	288
Custom work	156	209	212	135	147	207	202	179	140	151	170	79	113	80	89	69	61
Taxes	146	197	183	142	154	210	178	168	175	89	110	177	92	63	54	72	47
Other expense	285	315	351	387	344	370	415	376	290	222	277	339	206	143	118	240	161
Feed bought per T.A.	$ 7 81	$ 9 20	$ 10 33	$ 9 48	$ 17 46	$ 7 53	$ 6 38	$ 5 52	$ 7 43	$ 5 06	$ 7.17	$ 5.05	$ 3 89	$ 5.07	$ 2.80	$ 12.93	$ 8.96
Crop (less custom) Exp. @ T.A.	5 30	4 94	5 27	21 59	5 45	4 90	5 40	4 43	5 01	3 13	5.09	18.55	4.94	3.31	2.05	4.35	4.13
Custom work per T.A.	1 15	1 36	1 21	1 57	1 21	1 24	1 25	1 05	1 12	1 31	.23	.62	.85	.87	.74	.87	.87
Taxes per T.A.	1 08	1 29	1 04	1 67	1 27	1 26	1 10	97	1 41	78	.79	1.37	.69	.68	.45	.91	.68
Other expenses per T.A.	2 10	2 05	2 02	4 52	2 83	2 21	2 57	2 19	2 34	1 93	2 00	2 62	1.54	1.54	99	3.04	2.31

*Includes operator's and family labor but not interest on investment.
†Fruit farms excluded.

CROPS AND LIVESTOCK

Livestock continued to be the chief source of income on the average farm in this project. Livestock income averaged $5,897 per farm in 1949 which accounted for 70 percent of the total ($8,369). Of the remainder, 25 percent came from crops and 5 percent from miscellaneous sources.

In the livestock program, dairy was the most important enterprise. Of the 16 type-of-farming areas studied, 9 reported dairy cattle on every farm. Fourteen areas reported at least 95 percent of the farms having dairy cattle (Table 6). Farms reporting other kinds of livestock are as follows: 74 percent poultry, 60 percent hogs, and 12 percent sheep. The total livestock load in 1949 expressed in productive animal units averaged 25.6 compared with 23.9 in 1949 and 20.8 during 1935-39.

The cropping program is, of course, widely varied between the type-of-farming areas (Table 5). However, a farm which might be considered a composite of all areas would have the following use of the tillable land: "sod" crops, 43 percent; cultivated crops, 21 percent; grain crops, 28 percent; and idle fields or other crops, 8 percent.

With the exception of oats and barley, all crops averaged higher in yields in 1949 than in 1948 on these record-keeping farms.

SUMMARY

This report has attempted to summarize some of the capital requirements in farming and to present the average earnings of these somewhat above average Michigan farmers. Some of the changes taking place in farm operation were presented.

A detailed breakdown of financial and production data by type-of-farming areas is presented in Tables 4 to 7. A more comprehensive report for each area is available giving many efficiency and production standards based on the records of farmers in the respective areas. Locations of the type-of-farming areas of Michigan are shown in Fig. 1.

Area	Name
1.	Corn and Livestock
2.	Small Grains and Livestock
3.	Southwestern Fruit and Truck Crops
4.	Poultry, Dairy and Truck Crops
5.	Dairy and General Farming
6.	Dairy and Cash Crops
7.	Dairy, Hay, and Special Crops
8.	Beans, Sugar Beets, and Dairy
9.	Cattle, Sheep, and Forage
10.	Central Potato and Dairy
11.	Northern Fruit and Dairy
12.	Northern Potato and Dairy
13.	General, Self-Sufficing, and Part-Time
14.	Cattle, Potatoes, and Self-Sufficing
15.	Cattle, Hay, and Spring Grains
16.	Dairy and Potatoes
17.	Potatoes, Dairy, and Part-Time

Fig. 1. Types of farming in Michigan.

DEALING WITH MASTITIS ON THE FARM

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Dairy mastitis has existed ever since cows have been kept for milk production and will continue to exist as long as they are used for that purpose. Therefore, the most logical thing to do is to try to prevent and control the disease, using treatment only as one of the tools.

Mastitis is any inflammation of the udder. The abnormalities may be so slight and may develop so gradually as to go unnoticed, or the inflammation may be severe and cause general clinical symptoms. The condition may be infectious or non-infectious. Infectious means that the cause is a microbe. The microbe may be any of several; a staphylococcus, streptococcus, or one of the coliform group is the most frequent.

From a production standpoint, streptococcus infections are the most injurious because the form of mastitis they cause may persist for a long time before being noticed. This should awaken those dairymen who concern themselves with only the more spectacular type acute mastitis. Acute mastitis causes a marked decrease in production, swollen quarters, and grossly abnormal milk. The so-called hot-type infections are observed when the cow is off feed and off production; later, if she does not become a total loss by death, she is sold for slaughter. True, such cases are damaging to the individual production record, but because the symptoms are so vivid, they are usually given immediate veterinary attention.

The overall existant picture of infectious mastitis shows the presence of a much greater percentage of chronic or streptococcus infections. This is a progressive type that seemingly starts out unnoticed. Early chronic mastitis cannot be detected by gross observations of the udder and the milk, even though meticulously performed. A carefully conducted microscopic examination of aseptically collected incubated milk is the only way this insidious disease can be identified. In milk dollars, the chronic infectious mastitis syndrome is the most costly to the dairy farm of all dairy cattle diseases.

ARTICLE 33-22

A great deal of attention may well be given to the control of chronic mastitis. Proper and complete execution of good dairy husbandry principles is the key to any successful mastitis program.

The first consideration is the physical facilities for the care of the animals. Stables should have floors impervious to moisture. The length of the platform should be governed by the size and breed of cattle; consequently, any change in breed or size would necessitate a change in the platform. Dividers between stalls are essential to prevent injury to adjacent cows.

Crowding creates a definite hazard to the udders. Too much room leads to sprawling which is also a hazard to the udder. Ample dry bedding is a necessity. Damp and soiled bedding maintains bacterial reservoirs. Physical cleanliness throughout the stable reduces the possible sources of infectious agents. Barnyards and lanes should be kept free of water holes and filth. Manure should be handled so as to be inaccessible to the animals.

The next phase to consider in any program is that of the milking operation. Most dairy farms today use milking machines. Many farmers believe they were the beginning of our mastitis problem; many more realize that this is not necessarily the case. Their improper use, however, can be a deciding factor. With respect to the health of the udder, any milking machine that milks on both a vacuum and pulsation principle can be satisfactory.

The important thing to observe concerning any milking machine is its proper use. This includes care of the machine as well as preparation of the animal. A milking machine must be thoroughly clean for each milking. This necessitates washing with hot water and a detergent, and the use of brushes immediately following every milking. Particular attention should be directed toward the rubber inflations that contact the teats.

It is of great importance to make sure that the degree of vacuum is that which is recommended by the manufacturer. Too high a vacuum everts the end of the teat, causes erosion of the end of the teat, and unduly irritates the cisterns of the udder. Should infectious agents be in the inflation, such injuries provide easy access to the gland. The number of pulsations vary according to manufacturers' recommendations from 48 to 72 per minute. Pulsations that are too fast do not permit the milk to drain into and fill the teat cistern; thus an inefficient squeeze results. Properly timed pulsations allow proper filling of the cistern

and reduce possible irritation to the delicate lining tissue of the teat. The milking process should be a methodical, rhythmic procedure. It is unwise for one individual to attempt to handle more than two units. Cows should be washed with a warm disinfectant solution one minute before they are to be milked. This allows for the natural let-down to occur. A strip cup should be used to examine and discard the foremilk. Any quarter showing abnormalities should be milked separately.

The operator should familiarize himself as to the shortest time required to milk each individual cow. This milking time for individual cows will vary from 1½ minutes to, very seldom, over 5 minutes. Average cows will require 3 minutes. A machine should never be left on an animal any longer than is required to remove the milk. Stripping can be accomplished successfully by massaging the udder while exerting a slight pull on the claw with the other hand.

At the time of moving the machine from one cow to the next, the inflations should be rinsed in tempered water and dipped in a disinfectant solution. The milk line from the inflations to the machine or beyond must be open so as to permit these dip solutions to rise in the inflations when immersed into pails.

The milking chore requires the full attention of the operator. He cannot leave for even a few seconds to feed calves, grain animals or clean the gutter.

When mastitis is rampant in a herd, it is recommended that the simple, added precaution of dipping the end of the teats in a disinfectant solution at the completion of the milking of an animal is in order.

To demonstrate the value of the program, the experiences in two herds may be cited. These herds will be designated A-herd and B-herd.

The A-herd was a farmer's herd of 30 registered cattle. The physical facilities on the farm were adequate in all respects. The premises were average as to housekeeping. The Michigan State College Farm Veterinary Service records showed that a continued number of cases of acute mastitis were occurring on this farm.

On the initial survey all previously mentioned items were considered and necessary recommendations were made. One of the significant changes recommended was that clean cloths be used to wash the udders. On the first visit one small, well worn cloth was

being used in a single pail of disinfectant. It was suggested that a second pail be put in use so that inflations could be rinsed in water and dipped in a disinfectant solution. The water in both pails was to be changed at the half-way point in the milking line. The use of a strip cup was suggested. The cow was to be prepared one minute before the machine was placed on the cow. Feeding was to be completed before the milking chore commenced. At the time of the survey the operator planned to grain half of the herd while the first two cows were being milked, completing the feeding while the second group were being milked. Thus, machines were on 7 minutes and 8 minutes, respectively, for the first and second sets of cows.

All udders, upon physical examination, were classified according to amount of induration present. An aseptic composite milk sample was collected from each cow. In the laboratory direct microscopic examination was made of the incubated samples.

Eleven cows were infected with streptococci at the initial test. Physical examinations indicated that 10 were suitable subjects for treatment; one had a badly damaged udder but was treated.

These positive cows were placed last in the milking line and were treated with an indicated antibiotic. Samples collected one week following treatment showed that eight of the eleven positive animals had become free from infection. The three animals found to be still infected were successfully retreated, subsequently becoming negative to 10-day rechecks.

Subsequent monthly rechecks over a year's time showed that only two cases of mastitis occurred in this herd after the program was instituted. One of these was a dry cow at the time of the original survey. The second cow had a large pendulous udder, resulting in injury to the teat sphincter muscle which subsequently closed. Dilators were used in an attempt to obtain healing without permanent closure of the teat. The animal developed infectious mastitis, was treated and responded, but she became a very hard milker in that quarter. Later, because of her age, type and record, she was disposed of by slaughter.

Because of this herd management, untold money for treatment of acute mastitis was saved—to say nothing of the actual increased milk produced by disease-freed udders. The milk potential of the remaining animals was unimpaired, adding still more to the ultimate income of the dairyman.

In B-herd physical facilities were adequate, but housekeeping was poor. Recommendations to the herdsman were not faithfully carried out. Under those circumstances, the results of treatments were as expected, but overall benefits from the treatments were very discouraging. At one period 36 out of 56 milking cows were positive to streptococcus. A series of treatments reduced the incidence of infection to 8 cows out of a total of 54 milking cows. Sale for slaughter further reduced this number to 4 reactors in the herd, which at that time consisted of 50 animals. Later there were 58 animals in the herd, and 32 were reactors. The suggested strip cup sat on a window ledge covered by a winter's accumulation of dust and cobwebs. Cows were stabled according to production rather than according to health of the udder. Cows were wiped, a half-dozen at a time, without the cloth being rinsed. Abnormal milk from infected quarters was milked onto the floor and gutter. No quantity of drugs will control mastitis in such a herd until good husbandry practices are followed.

Antibiotics are of value only when mastitis is caused by infectious agents. These agents are of many species and should be identified to determine the antibiotic to be used. Therefore, accurate diagnosis is essential before rational treatment can be begun.

Indiscriminate use of antibiotics is also creating a serious problem for those in the cheese and cultured milk industries. The antibiotics affect the growth of cultures added to milk in the making of certain milk products, thus preventing the desired reaction. Many gallons of milk have become a total loss because a herd's milk in a vat contained sufficient antibiotic to inhibit proper development of the product. If such conditions continue, they will reflect in a reduction of total milk usage. A voluntary tagging plan on the part of the farmer, stating that cows, whose milk is included in shipment, have been treated with a specific antibiotic would prevent these losses. A plant knowing this could divert that milk to noncultural usage or treat milk with specific enzymes to counteract the antibiotic prior to introduction of culture.

JOURNAL ARTICLE ABSTRACTS

Reaction of Age Groups to Organoleptic Tests

Baten, William Dowell

Food Technology 4 (7): 277-279. 1950 [Journal Article 779 from the Michigan Agricultural Experiment Station]

Organoleptic tests were carried out on three types of materials, salty, sweet and sour, by judges in two age groups. The average age of the younger group was about 18, while that of the older group was between 35 and 40 years. This study showed that: a) young and more mature people do not evaluate certain types of food the same, b) young people distinguish differences between different strengths of materials when more mature people do not, c) it is well to test for differences between age groups composing panels before drawing conclusions, and d) there is a significant correlation between scores of the judges pertaining to sour materials and not pertaining to sweet and salty material.

A Practical Soil Moisture Meter as a Scientific Guide to Irrigation Practices

Bouyoucos, G. J.

Agronomy Jour. 42 (2): 104-107. 1950 [Journal Article 1063 from the Michigan Agricultural Experiment Station]

A simple, rapid, and practical method is presented to measure the available moisture content of soils, and to act as a scientific guide to irrigation practices. It indicates when and how much to irrigate the soil and how deep the applied water has penetrated the soil.

The method consists of an alternating-current impedance meter and a plaster-of-paris block with two electrodes imbedded inside. The method is intended for farmers, fruit growers, greenkeepers, florists and others to enable them to irrigate practically and economically. Although the moisture meter is intended for practical purposes, it is quite accurate and dependable. However, it is not intended to replace the soil moisture bridge for the more scientific work.

On account of capacitance effects arising from long wire leads, which result in erroneous moisture readings, the wire leads of the plaster-of-paris blocks should not be any longer than 10 feet. The moisture scale on the meter applies only to the plaster-of-paris blocks and not to the nylon units.

The method can be used as a guide to irrigation practice, not only in soils with average salt content, but also in soils containing rather large amounts of salts. The latter soils are irrigated at a higher level of available moisture content on the meter scale.

The plaster-of-paris blocks as made at the present time will last a long time in the soil, especially in well drained soils.

Freshly made or new plaster-of-paris blocks contain traces of soluble salts which affect slightly the readings at first. However, these salts readily disappear after the blocks are in the soil for 2 or 3 days.

Exposure of Incisor Roots in X-disease

WEBSTER, H. D.; HUFFMAN, C. F.; GRAY, M. L., AND THORP, F., JR.

M.S.C. Veterinarian 10 (1): 15, 16. 1949 [*Journal Article 1085 from the Michigan Agricultural Experiment Station*]

Exposure of the roots of the incisor teeth, a previously unrecorded lesion of X-disease, was reported in five animals recovering from the condition.

Precautions in the Use of Lanolin as an Assay Diluent for Plant Growth Substances

REDEMANN, C. T.; WITTWER, S. H., AND SELL, H. M.

Plant Physiology 25 (2): 356-358. 1950 [*Journal Article 1105 from the Michigan Agricultural Experiment Station*]

Lanolin has been found to contain sufficiently high concentrations of oxidizing agent(s) to interfere seriously with its use as a solvent for quantitative bio-assay of indole-3-acetic acid and for plant growth regulators in corn pollen. A method for removing the oxidizing agent from lanolin with sodium hydrosulphite is described.

The Role of the Air Line Hose of the Milking Machine in the Contamination of Milk

CHURCHILL, E. S., AND MALLMANN, W. L.

Jour. Milk and Food Tech. 13 (3): 137-145. 1950 [*Journal Article 1116 from the Michigan Agricultural Experiment Station*]

A study was made of 63 milking machine units on farms located in three separate milk sheds for the determination of the possible role that milking machine air line hoses play in the contamination of milk. It was found that proper cleaning and sanitizing of the milking machines were of more importance than the addition of any safeguards, such as milk traps on the air line, can possibly afford. The air line as a source of high bacterial counts was not significant when proper care in cleaning and sanitizing of the milking machine was accomplished. It was further pointed out that proper care of the milking machine should include proper cleaning and sanitizing of the air line hoses.

Our Agricultural and Trade Policies

WITT, L. W.

Jour. Farm Economics 32 (2): 159-175. 1950 [*Journal Article 1123 from the Michigan Agricultural Experiment Station*]

Substantial reductions have been made in United States tariffs. Data were shown on the extent of reduction. The tariff cuts have been about the same for agricultural and non-agricultural products. Non-tariff restrictions including quotas, licenses and cumbersome customs procedures and the difficulty of establishing low-cost sales outlets in the United States are now more important than the tariff in limiting greater imports of most goods.

The large volume of United States exports in recent years has been possible only because of large unilateral grants and loans by the United States. Readjust-

ments of the balance of payments is difficult. Non-tariff import restrictions limiting agricultural imports have been developed recently. They are listed in the paper. Many have resulted directly from high level agricultural price supports. Shifts in the form and/or level of price supports for agricultural products and a streamlining of customs procedures for industrial products are needed in efforts to close the trade gap.

Unless the conflict in trade and price support programs can be reconciled, increasing international economic pressures are likely to reduce the foreign market for agricultural export commodities, decrease the welfare of all of us as consumers, and lead to serious international political and trade conflicts.

Factors Contributing to the Utility as Food of Five Grades of Michigan Potatoes

PAUL, PAULINE; COLE, BETTY IVES, AND KNIGHT, KATHERINE C.

American Potato Journal 27 (5): 189-198. 1950 [*Journal Article 1130 from the Michigan Agricultural Experiment Station*]

Five grades of Michigan-grown potatoes and one of Maine-grown potatoes were compared for price, size, specific gravity, ascorbic acid, total solids, preparation waste, and sugar content. Three grades of the Michigan potatoes, and the Maine potatoes, were also compared for palatability. The potatoes were purchased at a retail market over a 3-month period, and were tested after laboratory storage of 1, 7 and 14 days. The grades of the Michigan potatoes were U.S. No. 1—M.P.D.A., U.S. No. 1, U.S. No. 1—size B, U.S. Commercial and U.S. No. 2. The Maine potatoes were grades U.S. No. 1—size A.

The Maine potatoes were the most expensive, the Michigan U.S. No. 1—size B the least, and the other Michigan grades decreased in price as the grade dropped. The Maine potatoes were the largest, the U.S. No. 1—size B the smallest, whereas the other four grades were intermediate and all about the same in size distribution. The Maine and the U.S. No. 1—size B were the most nearly even in size distribution, with each of the other grades covering a wider range of size within each sample.

The average specific gravities of all the different lots were quite similar, and all within the range which is considered to indicate a waxy texture. The U.S. No. 1—size B contained the most ascorbic acid. In most instances, the ascorbic acid content tended to decrease with room temperature storage. The total solids content of the potatoes differed more by purchase period than by grade or storage in the laboratory. All the potatoes gave a dark color with the picric acid test, indicating too high sugar content for use in deep fat frying. The preparation waste was greatest for the U.S. No. 1—size B and least for the Maine potatoes. The U.S. No. 2 had the highest preparation waste of the other four grades.

The U.S. No. 1—M.P.D.A. and Maine potatoes were quite similar in palatability, with the U.S. No. 1—size B and U.S. No. 2 similar to each other but lower in score than the first two. The color of the boiled and mashed potatoes became less desirable with storage, whereas the texture of the baked potatoes first increased, then decreased in score.

From the standpoint of price and ascorbic acid, the U.S. No. 1—size B potatoes were the best buy. With regard to preparation waste, and palatability, the U.S. No. 1—size A Maine potatoes were superior, with the Michigan U.S. No. 1—M.P.D.A., a close second.

The Effect of Vitamin B_{12}, APF and Streptomycin on the Growth of Young Pigs

LUECKE, R. W.; MCMILLEN, W. N., AND THORP, F., JR.

Archives of Biochemistry 26 (2): 326-327. 1950 [Journal Article 1132 from the Michigan Agricultural Experiment Station]

A basal ration composed of corn, soybean oil meal and minerals, fortified with vitamins A and D as well as commonly used B vitamins, was fed to a group of weanling pigs for a period of 6 weeks. The average daily gain of the pigs in this group was 0.88 pound. When vitamin B_{12} was added to the same ration and fed to another group of pigs the growth rate was increased by 10 percent. However, when pure streptomycin was added to this ration, another lot of pigs gained 40 percent faster than did the controls. The action of streptomycin in altering the intestinal flora of the pig may be related to the large increases in growth noted.

Carbohydrate Utilization in the Young Calf. I. Nutritive Value of Glucose, Corn Syrup and Lactose as Carbohydrate Sources in Synthetic Milk

FLIPSE, R. J.; HUFFMAN, C. F.; WEBSTER, H. D., AND DUNCAN, C. W.

Jour. Dairy Sci. 33 (8): 548-556. 1950 [Journal Article 1134 from the Michigan Agricultural Experiment Station]

Eighteen neonatal calves were allotted to three experimental groups and fed rations consisting of synthetic milks which varied only in the source of carbohydrate.

The average gain in weight for the 31-day experimental period was 9.33 pounds for glucose-fed calves (G), 8.66 pounds for corn syrup-fed calves (K) and 18.66 pounds for lactose-fed calves (L). The efficiency of feed utilization, expressed as the average of gain per pound of dry matter consumed, was 0.234, 0.142 and 0.384 for the G, K and L groups, respectively. Within the subgroups, 10- and 30-percent corn syrup produced fair results, while 45 percent was unsatisfactory. There was little difference in weight gains in response to lactose at the 5-, 10- and 30-percent levels.

Analysis of blood at weekly intervals for red cell volume, hemoglobin and plasma calcium, inorganic phosphorus, magnesium and ascorbic acid showed no apparent departure from the normal.

Examination of rumen samples for microorganisms revealed that individual differences were greater than differences between groups.

On post-morten examination, pneumonia, patchy congestion of the intestinal tract, abomasal petechial hemorrhages and ulceration about the pylorus were observed less frequently in the L than in G and K groups, while focal interstitial nephritis occurred indiscriminately in all groups.

Carbohydrate Utilization in the Young Calf. II. The Nutritive Value of Starch and the Effect of Lactose on the Nutritive Values of Starch and Corn Syrup in Synthetic Milk

FLIPSE, R. J.; HUFFMAN, C. F.; DUNCAN, C. W., AND WEBSTER, H. D.

Jour. Dairy Sci. 33 (8): 557-564. 1950 [Journal Article 1135 from the Michigan Agricultural Experiment Station]

Nine neonatal calves were placed in three experimental groups and fed rations consisting of synthetic milks which varied only in the carbohydrate component.

Calves receiving corn syrup plus lactose (KL) gained an average of 28.33 pounds, those receiving starch plus lactose (SL) gained an average of 24.67 pounds, while calves on starch (S) averaged only 14 pounds gain in 31 days. The efficiency of feed utilization, expressed as gain per pound of dry matter consumed, was 0.487, 0.412 and 0.204 for the KL, SL and S groups, respectively.

Serial blood samples were collected before a test meal and 0.25, 0.5, 1, 2, 4, 6 and 8 hours after feeding and were analyzed for blood sugar. The blood sugar level rose rapidly after the ingestion of glucose, lactose or corn syrup, with the maximum concentration at 4,4 and 1 hour, respectively, after feeding.

Following starch ingestion there was no change in blood sugar the first 4 hours and only a moderate increase at 6 and 8 hours.

Farm Land Acquisition Problems in Egypt

DAWOOD, HASSAN ALY

Land Economics 26 (3): 305-307. 1950 [*Journal Article 1137 from the Michigan Agricultural Experiment Station*]

Approximately three out of every four people in Egypt depend upon agriculture for their livelihood. Only a small portion of the country is suitable for farm use, and a high proportion of this is held by a relatively small number of owners.

Comparison of the land acquisition problems of Egypt and the United States shows that the farm laborer and tenant in Egypt have practically no opportunity to acquire ownership. Under 1945 conditions it would have taken the full farm wage of the average laborer for a 20-year period to buy the equivalent of one acre of farm land. The average farm tenant was no better off than the wage hands, and the agricultural credit system offers little, if any, help to the would-be owner.

Some Characteristics of Agricultural Land Leasing in Egypt

DAWOOD, HASSAN ALY

Jour. Farm Economics 32 (3): 489-495. 1950 [*Journal Article 1148 from the Michigan Agricultural Experiment Station*]

The tremendous pressure of the population against the available farm land in Egypt makes for high rents and considerable competition between prospective tenants for leases. Landowners can often secure more by renting their lands out than by trying to operate them themselves. Approximately two-thirds of the land is rented for cash. Very often this rent is collected in advance or before the crop is harvested. When land is rented out on a share basis, the owners sometimes receive as much as five-sixths of the crop.

Many leases cover only the time needed to grow one crop. Other leases may cover longer periods. Most of them run on a year-to-year basis. The usual lease involves only a verbal agreement. When the lease is in writing, there is often only one copy which is kept by the landlord. Sometimes the tenants sign blank leases and have the terms filled in later. In some cases, particularly where large areas are involved, leases are auctioned off to the highest bidders.

Effect of 2,4-Dichlorophenoxyacetic Acid on the Invertase, Phosphorylase and Pectin Methoxylase in the Stems and Leaves of the Red Kidney Bean Plants

NEELY, W. B.; BALL, C. D.; HAMNER, C. L., AND SELL, H. M.

Plant Physiology 25 (3): 525-528. 1950 [Journal Article 1155 from the Michigan Agricultural Experiment Station]

Invertase activity was absent in both the proliferated stem and leaf tissue of the red kidney bean plants treated with 2,4-dichlorophenoxyacetic acid and the controls.

Pectin methoxylase activity increased in both the proliferated stem and leaf tissue of the treated plants.

Phosphorylase activity decreased in both the proliferated stem and leaf tissue of the 2,4-D treated plants.

There was no indication of the presence of a phosphatase acting on D-glucose-1-phosphate.

Proposed Water Rights Legislation in Michigan

BARLOWE, RALEIGH

Land Economics 26 (3): 300-305. 1950 [Journal Article 1163 from the Michigan Agricultural Experiment Station]

Supplemental irrigation is rapidly becoming an important farming practice in many eastern states. Between 1945 and 1950 the irrigated area of Michigan increased almost twentyfold. With this increasing interest in irrigation, more and more attention must be given to the problem of water rights.

Michigan has no statutory legislation relating to the use of waters for crop irrigation. The use of waters from streams and lakes is covered by the riparian doctrine; but it is not certain how the courts will interpret this doctrine under Michigan conditions. Surface water rights legislation is needed to clarify this situation. A proposed law which involves an adaptation of tested principles of western irrigation law to the conditions of a subhumid area such as Michigan has been drafted to meet this need.

Penicillin Milk Levels in Cows Following Intramammary Administration

JACKSON, W. F., AND BRYAN, C. S.

Veterinary Med. 45 (10): 395-399. 1950 [Journal Article 1165 from the Michigan Agricultural Experiment Station]

Penicillin milk level curves obtained after the injection into the udders of cows of a variety of penicillin medication forms at the end, during the middle and near the start of the lactation period, are presented. In general, the highest levels were obtained at the end of lactation and the lowest levels at the beginning of the lactation period. The procaine penicillin in oil with aluminum monostearate gave measurable levels for the longest period of time. When 300,000 units was administered per quarter a measurable level of penicillin was obtained for 72 hours at the beginning of the lactation period. No other product studied maintained a measurable level for a similar period of time. When 25,000 units or more of penicillin of any medication form was administered to cows in all stages of lactation, measurable milk levels were obtained at the 24-hour sampling period in each case, and for longer periods of time during the latter part of the lactation period.

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